Comparing the efficacy of online vs. offline methods in modulating emotional responses through mental stress tasks

Luan Van Tran[1, 2], Anh Phuc Hoang Le[2, 3], Thao Thi Mai Le[2, 3], My Thi Tra Nguyen[1, 2], Quang Lam Nguyen[2, 3], Huong Thi Thanh Ha[2, 3*]

[1]Faculty of Biology and Biotechnology, University of Science, Vietnam National University - Ho Chi Minh City, 227 Nguyen Van Cu, Ward 4, District 5, Ho Chi Minh City, Vietnam
[2]Vietnam National University - Ho Chi Minh City, Linh Trung Ward, Thu Duc City, Ho Chi Minh City, Vietnam
[3]School of Biomedical Engineering, International University, Vietnam National University - Ho Chi Minh City, Quarter 6, Linh Trung Ward, Thu Duc City, Ho Chi Minh City, Vietnam

Received 21 December 2022; revised 20 March 2023; accepted 26 April 2023

Abstract:

Emotion regulation and stress represent two complex, intertwined processes. Yet, there is a paucity of studies examining the effect of stress on emotional regulation among Vietnamese students, specifically the influence of online and offline experimental conditions. This study investigates these dynamics by subjective assessment of the emotional responses of the subjects participating in this study. The research was structured in three primary phases: preliminary, online (conducted via the Internet), and offline (conducted in person) experiments. The preliminary phase (N=16) aimed to validate the appropriateness of the International Affective Picture System (IAPS) picture library and emotional stimulation videos from previous studies. Participants in the online (N=30) and offline (N=45) experiments were divided into control and stress groups, distinguished by the difficulty and urgency of the mental arithmetic task (MAT). Participants were then asked to view photos and videos and to rate their subjective feelings using the Self-assessment Manikin (SAM). The online experimental session revealed that subjects under acute stress exhibited heightened sensitivity, as indicated by increased valence scores in the positive and neutral groups, and decreased scores for negative imagery (Positive: MD=0.292, p=0.0113; Neutral: MD=0.245, p=0.001; Negative: MD=-0.435, p<0.0001). An increase in arousal scores in the stress group was also observed for positive (p<0.0001) and neutral sets (p<0.0001). However, these findings were not replicated in the offline experiment session. In conclusion, the IAPS pictures have proven suitable for emotional studies among Vietnamese students.

Keywords: **emotional response, offline experiment, online experiment, stress, Vietnamese student.**

Classification number: **3.6**

1. Introduction

Emotion regulation, the process by which individuals modulate their emotional experiences and expressions through various automatic and controlled physiological, behavioural, or cognitive processes, is critical for adaptive function and overlaps with stress-coping mechanisms throughout life [1]. Particularly, stress can negatively influence an individual's emotional state, often leading to an increase in rumination [2-4], which in turn increases the possibility of enhanced negative emotions [4]. Persistent negative emotions can result in mental disorders, thereby decreasing the quality of life. However, acute stress can also bring about some positive emotions [5, 6], underlying the importance of understanding the relationship between stress and emotional regulation. Additionally, the COVID-19 pandemic has underscored the importance of conducting experiments online, particularly in light of social distancing measures [7]. Indeed, social distancing during the pandemic can challenge cognitive performance via multiple elements [8], suggesting that participants' performance could vary between online and offline experimental settings, particularly considering the changes brought about during and after periods of social distancing. This study aims to clarify any potential differences between online and offline experimental environments.

University students represent one of the most stress-prone demographics within the Vietnamese population, with many factors contributing to this, including academic stress [9], familial expectations, and peer pressure. Moreover, a high prevalence of mental disorders, such as stress, anxiety, and depression, has been reported among Vietnamese university students [10]. Stress can have detrimental effects on a student's lifestyle, such as causing reductions in cognitive performance [11], which often culminates in poor academic performance [12]. Stress also impacts the three components of emotions: arousal (ranging from a state of calm to excitement or agitation post-stimulus) [13-15], valence (indicating a spectrum from extremely negative to highly positive, or the pleasantness of the stimulus) [15, 16], and dominance (the capacity to control one's emotions following a stimulus) [16]. Notably, stress is responsible for an increase in emotional distress, leading to an increase in arousal [13-15] and a decrease in valence [15, 16]. Despite these findings, no research to date has specifically focused on these three components of emotion (valence, arousal, and dominance) among Vietnamese university students following exposure to stressors. Furthermore, there is a lack of suitable picture and video libraries targeting this demographic. As such, there is a pressing need to assess the emotional responses of Vietnamese university students after encountering acute stress. Such understanding would provide valuable insights into how stress can affect emotional responses, especially within the Vietnamese student population.

Consequently, this study will comprise three experimental stages: preliminary, online, and offline. For the preliminary phase, a set of images from the International Affective Picture System (IAPS) libraries and various categories of videos will be used to determine

*Corresponding author: Email: htthuong@hcmiu.edu.vn

their suitability for evaluating the emotional responses of Vietnamese university students. This evaluation will be critical not only for this project, but also future research related to the emotional responses of Vietnamese students. Subsequently, the selected library of pictures and videos will be used in both the offline and online phases to evaluate the emotional response of Vietnamese students, focusing on changes in valence, arousal, and dominance after experiencing acute stress induced by Arithmetic Tasks.

2. Subject and methodology

2.1. Study design

This study comprised three main phases: the preliminary, online, and offline phases (Fig. 1). In the preliminary phase, volunteers completed experiments and a subsequent SAM survey to select appropriate pictures for the emotional trigger task. These images and videos were then used to develop the platform for the main experiment (both offline and online phases), which was divided into three parts: 1) Stress induction or control protocol via the MAT; 2) Emotional triggers involving ninety pictures or five videos; 3) A mid-experiment Stroop Effect Task to assess the attention of the participants. The study's second phase, conducted remotely (online) during the COVID-19 quarantine via Zoom and AnyDesk, spanned two months. The final phase, carried out in person (offline) at the International University, Vietnam National University, lasted six months. At the start of both the online and offline phases of the main experiment, participants were asked to fill out a pre-screened questionnaire to record their current physical and mental states. The video sessions were scheduled two to three weeks after the picture sessions. The platform was displayed on the computer screen via PsychoPy software, with participants responding to the task by typing on the keyboard.

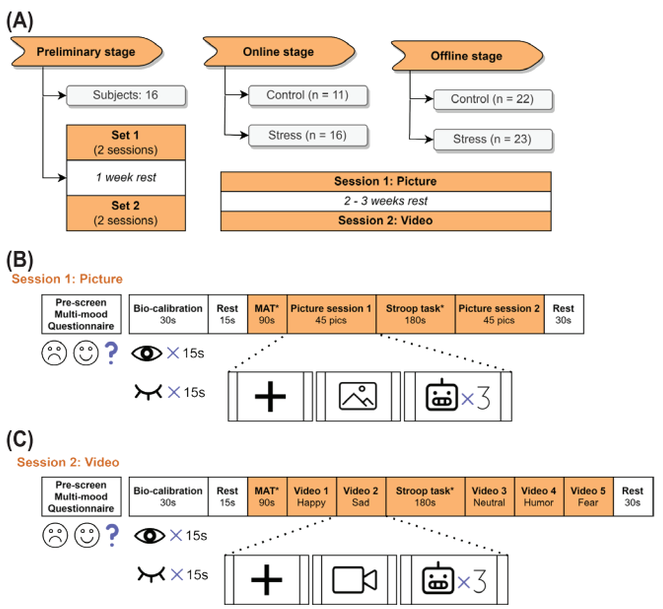


Fig. 1. The three-phase experimental design: preliminary, online, and offline (A); platform design of the first experiment with 90 pictures inducing positive, neutral, or negative emotions (B); the design of the second experiment with five videos inducing pleasure, sadness, neutral, amusement, and fear (C).

2.2. Participants

Ninety-five subjects were recruited to participate in this study, including sixteen subjects for the preliminary phase, thirty subjects for the online phase, and forty-nine subjects for the offline phase. All participants were college students of ages between 18 and 25 years old. The demographic information of the subjects is summarized in Table 1. Before their participation, subjects were screened to ensure consistency in physical and mental health in the same manner as in similar studies [17, 18]. All participants signed an informed consent form before participating in the experiment. The study protocol was approved by the School of Biomedical Engineering, International University, Vietnam National University - Ho Chi Minh City.

Table 1. Demographic information of participants in the three phases.

Phase	Prelim (N=16)	Online (N=30)		Offline (N=45)	
Group	N/A	Control	Stress	Control	Stress
N	16	11	19	22	23
Gender (M/F)	6/10	1/10	4/15	4/18	9/14
Age (Mean±SD)	21.45±1.95	21.09±1.04	21.32±1.42	20.33±0.92	20.48±1.6

M: male; F: female; SD: standard deviation; N/A: not applicable.

2.3. Picture and video selection

This study selected images and videos used as emotional stimuli based on previous studies on emotional elicitation and responses [19-21]. The pictures for this study were sourced from the IAPS database (http://csea.phhp.ufl.edu/media/iapsmessage.html), a renowned resource offering approximately 900 images for the evaluation of human emotions [22]. The emotional rating of pictures within IAPS is characterized by three values: arousal, dominance, and valence. We selected a total of 40 pictures from IAPS, incorporating three categories: negative, neutral, and positive pictures. This selection was based on the valence value, the exclusion of alarming keywords, and arousal scores (i.e., neutral images have the lowest arousal scores, while negative and positive images have the highest arousal scores). These pictures were subsequently divided into two sets for the preliminary assessment.

For the selection of videos, we relied on the emotional clips documented by [23] and divided them into two sets. Each set included five types of emotional triggers: Pleasure, Sadness, Neutral, Amusement, and Fear. A detailed description of the two sets of videos is summarized in Table 2.

Table 2. Description of selected videos for the preliminary phase.

Emotion	Duration (seconds)	Description
Set 1		
Pleasure	88	A girl is giving a speech at the graduation ceremony.
Sadness	180	The daughter's regret at the father's sacrifice
Neutral	97	Drive on a mountain road
Amusement	350	A poor man and a rich man sleep together
Fear	103	Ghosts hang up people in their house
Set 2		
Pleasure	39	A happy conversation between father and son
Sadness	274	Thoughts of an abandoned dog
Neutral	97	Drive on a mountain road
Amusement	190	Teachers' funny competition
Fear	120	An aggressive blind woman in the hospital

2.4. Platform design

The platform of this study was developed and executed by PsychoPy Software version 2021.2.3, running on Python 3.8. The experiment comprised two sessions: one involving pictures (Fig. 1B) and the other, videos (Fig. 1C). At the start of each session, a 30-second bio-calibration was performed (including 15 seconds with eyes open and 15 seconds with eyes closed), followed by a 30-second rest period. Subsequently, the MAT was displayed for 90 seconds, featuring a high difficulty level as an acute stress inducer for the test group, and a lower difficulty level for the control group.

After the stress-inducing step, subjects were exposed to emotional photographs or videos. For the picture session, subjects were given a three-second rest period before each photo was displayed for five seconds. Subsequently, participants were required to respond to the Manikin survey, assessing valence, arousal, and dominance, within 15 seconds (five seconds per question). This procedure was repeated 90 times (i.e., 90 trials), with the photographs displayed randomly. After the presentation of 45 pictures, the Stroop Task was conducted for 180 seconds before continuing the picture session. In the video session, the procedure mirrored the picture session, including a four-second rest period, emotional video stimulation, and a 15-second Manikin assessment. The videos were shown in the following order: Pleasure, Sadness, Neutral, Amusement, and Fear, with the Stroop Task presented after the Sadness video. Finally, at the conclusion of the experiment, subjects were given a 30-second rest period.

2.5. Emotions and mood self-evaluated scales

2.5.1. Momentary mood state measures

The momentary mood state measures (MMSM) were conducted to analyse participants' moods before each experiment session. This 15-item measure utilized a 5-point Likert-type rating scale to evaluate 7 aspects of a positive state: happy, cheerful, proud, relaxed, cooperative, caring, and friendly, and 8 aspects of a negative state: angry, nervous, lonely, frustrated, strained, worried, irritated, and stressed [24]. The measures were translated into the participants' native language (i.e., Vietnamese) and revised by expert psychologists.

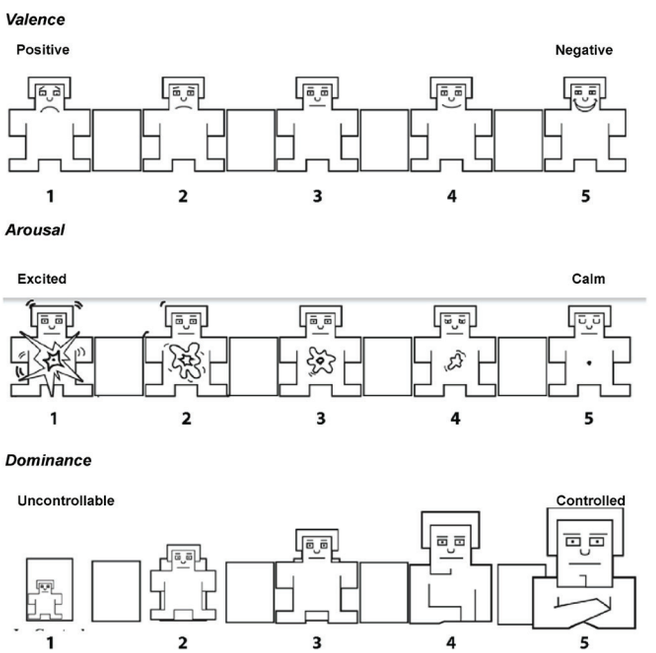


Fig. 2. The self-assessment Manikin scale measuring valence, arousal, and dominance [27].

2.5.2. Self-assessment Manikin

The SAM is a non-verbal measure of the three directions of emotional response including valence, arousal, and dominance [25, 26]. In this study, we used a 5-point scale to measure the score of each direction in response to the three categories of IAPS images and videos. The SAM scale is shown in Fig. 2.

2.6. Mental arithmetic task

The MAT was used as a stress-inducing task [18, 28, 29]. Participants were tasked with solving a set of arithmetic problems. For the control group, basic calculations involving the addition and subtraction of three digits ranging from one to ten were provided, with no time limit set for each calculation. Conversely, the stress group was assigned more complicated calculations, including the addition, subtraction, and multiplication of three integers less than 100. Participants in this group were allotted three seconds to perform each calculation, with a total time limit of 90 seconds for the entire MAT section. Subsequently, we used a 7-point Likert-type rating scale to survey their perception of the task's difficulty and stress levels.

2.7. Data analysis

The responses to the pre-screen questionnaire were queried on a Google Answer Spreadsheet. The picture and video session results were extracted from a *.csv* file exported by PsychoPy, including the MAT and Manikin responses. Any mistyped values were considered as missing values. Subjects with more than 30% of values missing were excluded from the study.

2.8. Statistical analysis

All data in this study were illustrated as mean±standard error of the mean (SEM) and analysed by the one-way analysis of variance (ANOVA) test and *t-test*. Statistical analysis was performed using a 0.05 level of significance and conducted by GraphPad Prism software, version 8.3.1.

3. Results

3.1. Identification of picture and video library to induce emotional response

We analysed the self-evaluated Manikin scale distribution from the preliminary phase to identify suitable pictures and videos that could elicit emotional responses in Vietnamese students. Figs. 3A, 3D illustrate that the videos in Set 2, which induced positive emotion, showed a score distribution entirely on a positive scale. This result affirms the suitability of these videos in Set 2 for inducing emotional responses of pleasure and amusement subsequent experiments. Regarding sadness-triggered videos, the distribution of Set 1 focused more on the positive valence than Set 2 (Fig. 3B). This suggests that the footage in Set 1 stimulated more than one emotion. Therefore, the sadness video in Set 2 was chosen for the subsequent experiments. Two videos designed to trigger fear exhibited no difference on both valence and arousal scales (Fig. 3E). Overall, the videos in Set 2 proved to be a better fit for the purpose of

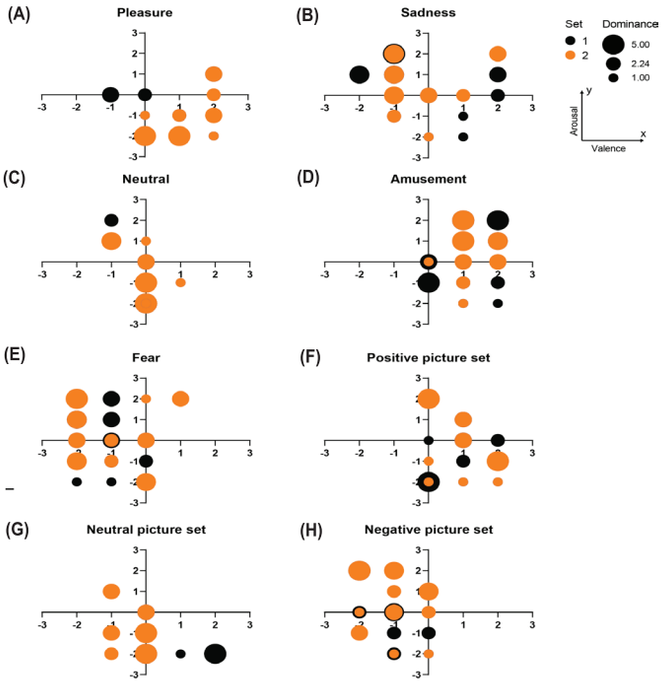


Fig. 3. The self-evaluated Manikin scale distribution of pictures and videos from the preliminary phase. Videos were targeted to induced specific emotional responses: **(A)** Pleasure, **(B)** Sadness, **(C)** Neutral, **(D)** Amusement, and **(E)** Fear. Pictures were targeted to induce the following specific emotional responses: **(F)** Positive, **(G)** Neutral, and **(H)** Negative (Set 1: N=16; Set 2: N=16). Each circle represents the mean value. The size of the circle indicates the mean value of the dominance scale.

the experiment and were implemented in subsequent experiments. The pictures from both sets yielded valence and arousal scores that aligned with their designated emotions, namely positive, neutral, and negative, with no discernible differences (Figs. 3F-3H). After removing outlier pictures whose valence scores did not correspond with the expected emotional activation, 45 images for each emotion type were randomly selected from both sets for further experiments.

3.2. Evaluation of the stress-inducing effect using mental arithmetic task

Independent t-tests were initially conducted on the participants' feedback regarding difficulty and stress levels to determine the stress-inducing effects of MAT under both online and offline experimental conditions. When comparing the two groups, the stress group reported significantly higher levels of difficulty (MD=2.291±0.4193, p<0.0001, Fig. 4A) and stress (MD=1.465±0.3679, p=0.0002, Fig. 4B). This result is consistent with the subjects' performance presented in Fig. 4C, where the control group achieved significantly higher accuracy in all evaluated sessions (p<0.0001). Particularly, in the first online experimental session, the control group surpassed the stress group by 83.74±6.380%. This gap slightly decreased in the second session to 68.97±5.926%. A similar trend was observed in the offline experiments, wherein the first session, the control group surpassed the stress group by 67.31±4.324%, and in the second session, the accuracy gap was reduced to 46.61±4.512%. Notably, significant differences were found within the stress cohorts between the two experimental conditions. Regarding arithmetic tasks for the stress groups, the offline cohort yielded significantly higher accuracy in both experimental trials (first trial: MD=15.06±4.980, p=0.0119; second trial: MD=19.80±4.972, p=0.0004). In contrast, the control group showed no difference between the two experimental conditions. The difference in accuracy exhibited by the stress group between two experimental conditions, online and offline, is hypothesized to be influenced by the COVID-19 quarantine and will be further elucidated in the following section.

3.3. The difference between offline and online platforms in emotional response

Differences in emotional response between two experimental groups, control and stress, were evaluated through three parameters: valence, arousal, and dominance. In the first experimental session of the online cohort, an elevated sensitivity was evident in subjects' responses to all picture sets: the valence differed significantly in all sets, with the stress group deviating in emotional tendencies (Positive: MD=0.292, p=0.0113; Neutral: MD=0.245, p=0.001; Negative: MD=-0.435, p<0.0001). The stress-induced group also experienced more intense emotions, reflected in higher arousal scores, particularly noticeable in positive (p<0.0001, Fig. 5A) and neutral sets (p <0.0001, Fig. 5B). This trend persisted in the second session using video stimulation, as the stress group sustained their valence deviation more notably than the control group (Supplementary Fig. 1). However, this trend did not apply to sadness (MD = 0.11) as the stress group showed a slightly higher valence score compared to the control (Supplementary Fig. 1B). Nevertheless, the arousal scores were consistently higher in the stress group across all emotions (significantly higher in positive and neutral, MD=0.32-0.52, respectively, p<0.0001), suggesting they were experiencing more intense emotions (Fig. 5).

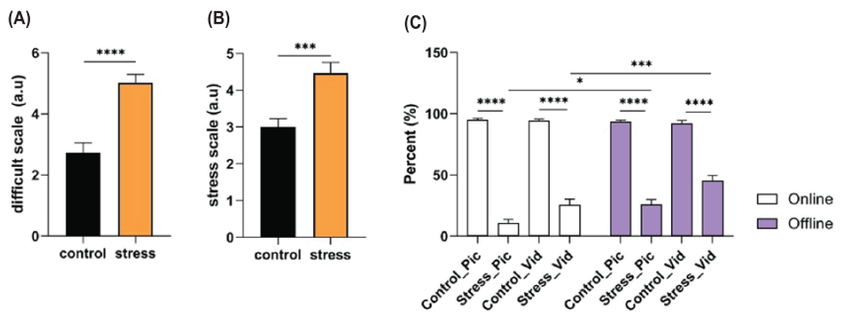


Fig. 4. The participants' self-evaluated difficulty and stress levels when performing mental arithmetic tasks in the control and stress groups. (A) Difficulty; **(B)** Stress level; **(C)** The results from the mental arithmetic task of the control and stress groups. Control online: N=11, stress online: N=16, control offline: N=22, stress offline: N=23.

In the first experimental session of the offline platform, no differences were observed between the two groups (Fig. 6). Overall, both groups expressed emotional valence in alignment with the intended mood as they responded with high valence scores to positive pictures (Fig. 6A) and low valence scores to negative pictures (Fig. 6C). On the other hand, the stress group experienced more intense emotions, as evidenced by their arousal score, especially in response to positive pictures (MD=0.169; p=0.0341, Fig. 6A). In the second session, which involved video stimulation, there was no significant difference detected between the two experimental groups, similar to the online cohort (Supplementary Fig. 2).

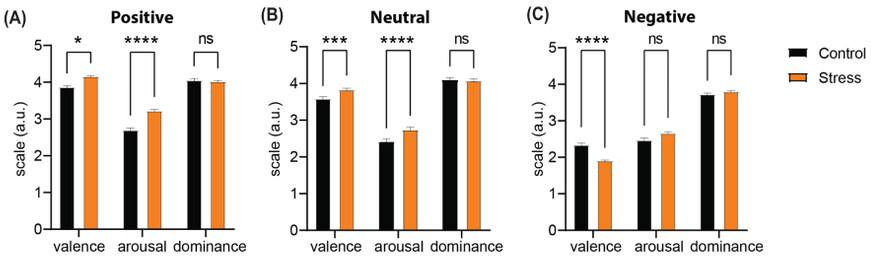


Fig. 5. Comparing emotional response levels of the two experimental groups in the online session to pictures of specific emotional triggers through the Manikin emotional self-rating scale. (A) Positive (control: n=487, stress: n=828); **(B)** Neutral (control: n=244, stress: n=428); **(C)** Negative (control: n=245, stress: n=418) (online control: N=9, online stress: N=15).

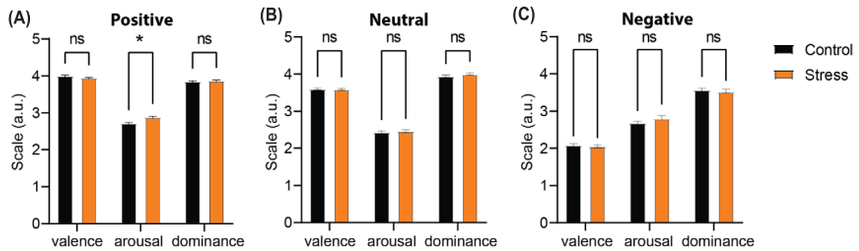


Fig. 6. Comparing the emotional response levels of the two experimental groups in the offline session to pictures of specific emotional triggers through the Manikin emotional self-rating scale. (A) Positive (control: n=720, stress: n=671); **(B)** Neutral (control: n=720, stress: n=673); **(C)** Negative (control: n=1433, stress: n=1305) (online control: N=25, online stress: N=24).

Subsequently, multiple comparisons were conducted on participants' mood evaluations to highlight any potential differences between two experimental cohorts, namely online and offline. As illustrated in Fig. 7, it can be deduced that the offline cohort experienced more intense emotions. This observation is based on the overall trend where offline subjects provided higher intensity ratings for 13 out of 15 evaluated moods. Notably, 9 out of these 15 moods demonstrated significant differences between the two cohorts, including happiness (p=0.00352), cheerfulness (p=0.00611), pride (p=0.0126), nervousness (p=0.000480), loneliness (p=0.000185), frustration (p=0.0263), strain (p=0.0134), worry (p=0.00145), and stress (p=0.00484). Particularly, the most distinctive moods were loneliness (MD=0.501) and nervousness (MD=0.400). These results implied a heightened sensitivity in the offline cohort's emotions prior to intervention compared to the online cohort, which may be related to the respective cohort's living conditions. This point will be elaborated in the next section.

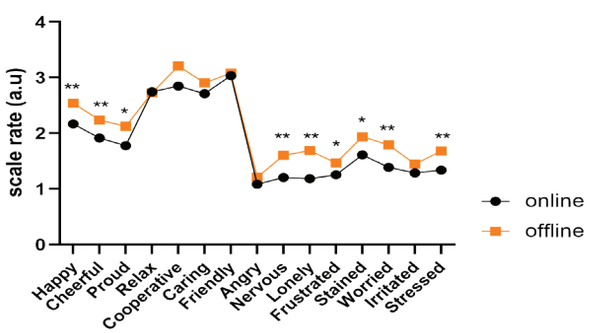


Fig. 7. Mean of momentary mood states measure scale in the online and offline experiments.

4. Discussion

Numerous prior studies have explored the suitability of the IAPS library in emotional responses, cognition, and regulation across various socio-cultural contexts [21, 30, 31]. However, given socio-cultural differences, the impact of the IAPS library on Vietnamese students has not been established, nor has any effort been made to build a library of images and videos to support studies of emotional responses in Vietnamese individuals. Our preliminary results suggest that our designated IAPS library evokes emotions in Vietnamese students in a manner similar to trends observed in previous studies [21, 22, 30]. Both IAPS libraries (Sets 1 and 2) effectively induced emotions as indicated by their labels: high scores on the valence scale for positively induced emotions (>0), low scores for negatively induced emotions (< 0), and scores ranging from -1 to 1 for neutral picture sets [30]. Similarly, the results for each emotional-inducing video also displayed valence scores consistent with each type of emotion.

The differences in self-rating stress and difficulty levels, as well as arithmetic accuracy, between the two experimental groups (Fig. 4) were similar to those found in previous studies [18, 32, 33]. These results demonstrate that the designated MAT is capable of inducing acute stress in the stress group. MAT performance is commonly used to assess the level of working memory involved in cognitive processing [34-36]. Interestingly, the accuracy achieved by the online stress group was found to be significantly lower than that of the offline stress group (Fig. 4C). This difference implies the effect of environmental factors on subjects' MAT performance in the two experimental conditions: online or offline. Previous studies have shown a negative association between anxiety and working memory task performance [37]. In our study, the two experimental stages were conducted during different periods of the COVID-19 pandemic - the online phase took place at the end of the COVID-19 quarantine period, and the offline phase occurred during the resurgence of SARS-CoV-2 infections [38]. We hypothesize that the pandemic outbreak during the offline phase may have caused anxiety among the stress group, which could explain the higher performance in MAT among the offline stress cohort.

Previous studies have demonstrated the effects of acute stress on emotional sensitivity and recognition in experimental subjects [19, 39]. The online experimental results showed that MAT heightened awareness of positive and negative emotions in the stress groups by increasing the valence score in the positive and neutral emotion-triggered picture sets and decreasing it in the negative emotion-triggered set (Fig. 5). Sensitivity was also enhanced, as evidenced by an increase in arousal scores regardless of emotion types. However, this trend was not as significant in the offline experiments: Only the positive picture set recorded a substantial increase in the stress group's arousal score (Fig. 6A), while two other picture sets only saw a slight increase (Figs. 6B, 6C). On the other hand, a higher negative valence score and lower scores in neutral and positive valence scores were found in the offline stress group compared to the online group. Regarding the control group, there

was no difference between the two experimental conditions. This result suggests that the online cohort was more sensitive in their emotional responses. Previous studies have clarified the positive correlation between social stressors and negative emotional responsiveness and perception [6, 40]. Therefore, environmental stressors during the online session are hypothesized to be the primary cause of different emotional responses between the two experimental conditions. It is noteworthy that the online experiment was conducted during the easing of social lockdown, and the offline experiment was conducted during the "new normal" - after the COVID-19 lockdown had been lifted. So, were environmental factors involved in subjects' emotional resilience in two experimental conditions?

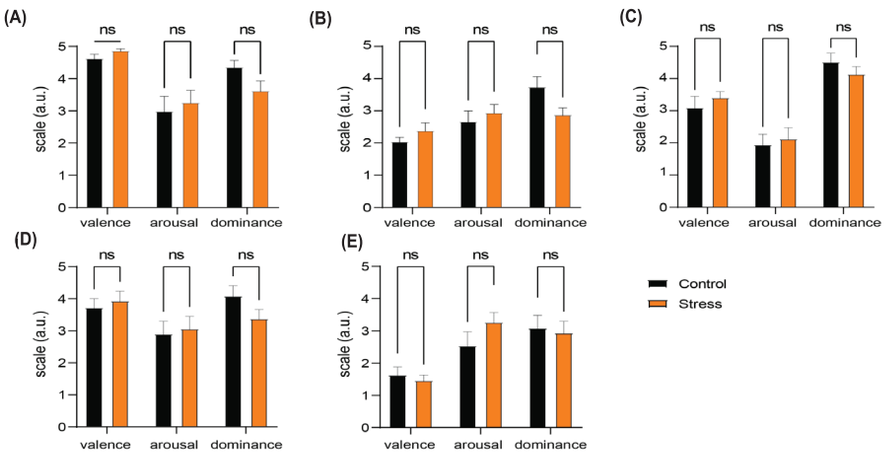
The impact of the COVID-19 pandemic can be inferred from the analysis of Mean of Momentary Mood States Measure (MMSM) results (Fig. 7). The offline cohort exhibited higher intensity ratings for 13 out of 15 surveyed moods. This trend indicated an increase in mood instability in young adults [41]. Studies investigating the effects of stress posed by the COVID-19 pandemic on mood swings after lockdown have been documented in other countries [42, 43]. However, the Vietnamese population reported lower stress level than other countries in the region and developed countries [44]. Students under social lockdown reported that being with their families during the pandemic partly reduced their core stressors, such as tuition fees, living alone, and transportation problems [45]. In contrast, at the time of the offline experiment, students had returned to study on campus, and problems such as job loss, financial crises of sponsors, and living away from home affected students. Furthermore, between March and May, there was a sudden increase in SARS-CoV-2 infections [38]. These unique circumstances might explain the difference in mental health between the online and offline cohorts. However, there have been limited studies investigating the influence of post-lockdown social factors on students' mental health. Further work needs to be conducted to clarify the relationship between these two factors.

5. Conclusions

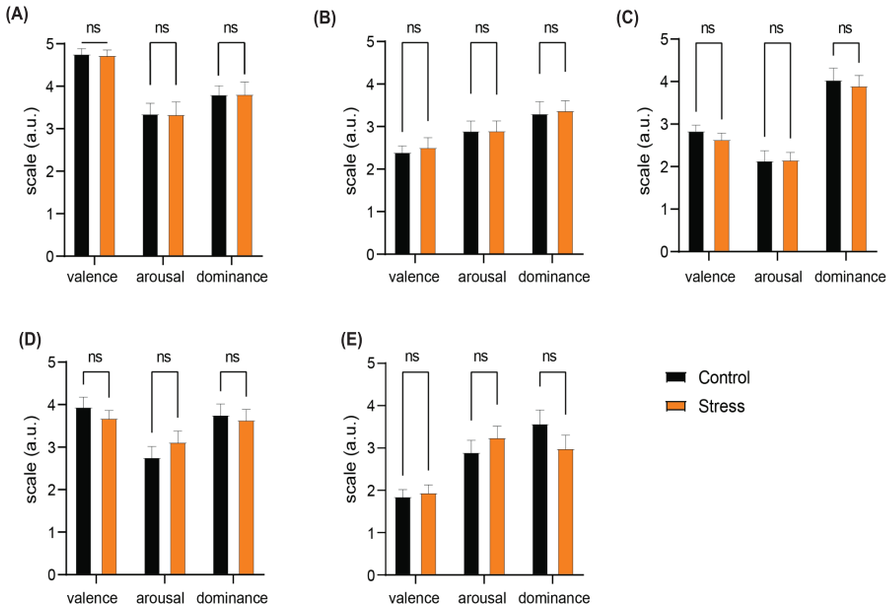
To date, no picture or video library has been specifically designed to trigger emotional responses in Vietnamese individuals. The impact of acute stress on emotional responses in Vietnamese students also remains unexplored. This pioneering study demonstrates that the IAPS picture and video libraries, adapted from foreign studies, effectively trigger emotions in Vietnamese students consistent with their designated labels. Consequently, a selection of IAPS pictures and videos was implemented in subsequent experiments to evaluate the effects of acute stress on emotions in this demographic.

The online experiments revealed that subjects under acute stress were more sensitive across three emotional categories via increased valence scores in the positive and neutral groups and decreased scores for negative pictures. This emotional sensitivity was also reflected in arousal scores of each emotion. However, a similar significance was not observed in the offline experiment. Through the MMSM results, increases in both positive and negative states were noted among subjects in the offline experiment. These findings suggest the potential influence of social factors, such as COVID-19 - considering the timing of the experiments - on participants' mental health. In one interpretation, these results underscore the enduring impact of the COVID-19 crisis on the mental health of Vietnamese students.

SUPPLEMENTARY



Supplementary Fig. 1. Comparison of the emotional response levels of the two experimental groups in the online session to videos of specific emotional triggers through the Manikin emotional self-rating scale. (A) Pleasure; **(B)** Sadness; **(C)** Neutral; **(D)** Amusement; **(E)** Fear. Online control: N=11, online stress: N=19.



Supplementary Fig. 2. Comparison of emotional response levels of the two experimental groups in the Offline session to videos of specific emotional triggers through the Manikin emotional self-rating scale. (A) Pleasure; **(B)** Sadness; **(C)** Neutral; **(D)** Amusement; **(E)** Fear. Offline control: N=22, offline stress: N=23.

CRediT author statement

Luan Van Tran: Conceptualisation, Project administration, Software, Investigation, Methodology, Data analysis, Writing, Editing; Anh Phuc Hoang Le: Methodology, Investigation, Data analysis, Writing, Editing, Reviewing; Thao Thi Mai Le: Methodology, Writing, Editing; My Thi Tra Nguyen: Investigation, Data analysis, Writing, Reviewing; Quang Lam Nguyen: Investigation, Writing, Reviewing, Editing; Huong Thi Thanh Ha: Supervision, Resources, Conceptualisation, Reviewing, Funding acquisition.

ACKNOWLEDGEMENTS

This research is funded by the ADAI Fellowship. We would like to express our sincere thanks to the parents of each research team member who were to give birth, foster, educate, and love us unconditionally. We would also like to give special thanks to Bao Hoai Pham, Thien Hoang Minh Cao, Tri Nguyen Minh Huynh, Chau Vu Minh Trieu, Tuong Huu Nguyen, and Dung Lam Quoc Pham for their help during data collection.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

REFERENCES

[1] K.N. Ochsner, J.J. Gross (2005), "The cognitive control of emotion", *Trends in Cognitive Sciences*, **9(5)**, pp.242-249, DOI: 10.1016/j.tics.2005.03.010.

[2] C.M.E. Richardson (2017), "Emotion regulation in the context of daily stress: Impact on daily affect", *Personality and Individual Differences*, **112**, pp.150-156, DOI: 10.1016/j.paid.2017.02.058.

[3] R.S. Lazarus (2006), *Stress and Emotion: A New Synthesis*, Springer Publishing Company, 360pp.

[4] J. Du, J. Huang, Y. An, et al. (2018), "The relationship between stress and negative emotion: The mediating role of rumination", *Clinical Research and Trials*, **4(1)**, pp.1-5, DOI: 10.15761/CRT.1000208.

[5] V.L. Kinner, S. Het, O.T. Wolf (2014), "Emotion regulation: Exploring the impact of stress and sex", *Frontiers in Behavioral Neuroscience*, **8**, DOI: 10.3389/fnbeh.2014.00397.

[6] K. Langer, B. Hagedorn, L.M. Stock, et al. (2020), "Acute stress improves the effectivity of cognitive emotion regulation in men", *Scientific Reports*, **10(1)**, DOI: 10.1038/s41598-020-68137-5.

[7] N.S. Wigginton, R.M. Cunningham, R.H. Katz, et al. (2020), "Moving academic research forward during COVID-19", *Science*, **368(6496)**, pp.1190-1192, DOI: 10.1126/science.abc5599.

[8] A.M. Henneghan, K.A. Lewis, E. Gill, et al. (2022), "Cognitive impairment in non-critical, mild-to-moderate COVID-19 survivors", *Frontiers in Psychology*, **13**, DOI: 10.3389/fpsyg.2022.770459.

[9] N.P. Tuan, N.N. Quy, N.T.T. Huyen, et al. (2020), "Factors influencing academic stress on the students of the VNU University of Economics and Business", *VNU Journal of Economics and Business*, **36(3)**, DOI: 10.25073/2588-1108/vnueab.4380 (in Vietnamese).

[10] N.T.H. Tuyen, T.Q. Dat, H.T.H. Nhung (2019), "Prevalence of depressive symptoms and its related factors among students at Tra Vinh University, Vietnam in 2018", *AIMS Public Health*, **6(3)**, pp.307-319, DOI: 10.3934/publichealth.2019.3.307.

[11] K. Martin, E. McLeod, J. Périard, et al. (2019), "The impact of environmental stress on cognitive performance: A systematic review", *Human. Factors*, **61(8)**, pp.1205-1246, DOI: 10.1177/0018720819839817.

[12] T.H. Macan, C. Shahani, R.L. Dipboye, et al. (1990), "College students' time management: Correlations with academic performance and stress", *Journal of Educational Psychology*, **82(4)**, pp.760-768, DOI: 10.1037/0022- 0663.82.4.760.

[13] S.A. Christianson (1992), "Emotional stress and eyewitness memory: A critical review", *Psychological Bulletin*, **112(2)**, pp.284-309, DOI: 10.1037/0033-2909.112.2.284.

[14] M. Wang, K.J. Saudino (2011), "Emotion regulation and stress", *Journal of Adult Development*, **18**, pp.95-103, DOI: 10.1007/s10804-010-9114-7.

[15] E.A. Kensinger (2004), "Remembering emotional experiences: The contribution of valence and arousal", *Reviews in The Neurosciences*, **15(4)**, pp.241-251, DOI: 10.1515/REVNEURO.2004.15.4.241.

[16] A.B. Warriner, V. Kuperman, M. Brysbaert (2013), "Norms of valence, arousal, and dominance for 13,915 English lemmas", *Behavior Research Methods*, **45(4)**, pp.1191-1207, DOI: 10.3758/s13428-012-0314-x.

[17] American Psychiatric Association (2013), *Diagnostic and Statistical Manual of Mental Disorders: DSM-5™* (5th Ed.), DOI: 10.1176/appi.books.9780890425596.

[18] A. An, H. Hoang, L. Trang, et al. (2022), "Investigating the effect of mindfulness-based stress reduction on stress level and brain activity of college students", *IBRO Neuroscience Reports*, **12**, pp.399-410, DOI: 10.1016/j.ibneur.2022.05.004.

[19] G. Domes, P. Zimmer (2019), "Acute stress enhances the sensitivity for facial emotions: A signal detection approach", *Stress*, **22(4)**, pp.455-460, DOI: 10.1080/10253890.2019.1593366.

[20] D. Liao, L. Shu, G. Liang, et al. (2020), "Design and evaluation of affective virtual reality system based on multimodal physiological signals and self-assessment manikin", *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, **4(3)**, pp.216-224, DOI: 10.1109/JERM.2019.2948767.

[21] A.P. Soares, A.P. Pinheiro, A. Costa, et al. (2015), "Adaptation of the international affective picture system (IAPS) for European Portuguese", *Behavior Research*, **47**, pp.1159-1177, DOI: 10.3758/s13428-014-0535-2.

[22] M.M. Bradley, P.J. Lang (2007), "The international effective picture system (IAPS) in the study of emotion and attention", *Handbook of Emotion Elicitation and Assessment*, pp.29-46.

[23] Y. Deng, M. Yang, R. Zhou (2017), "A new standardized emotional film database for Asian culture", *Frontiers in Psychology*, **8**, DOI: 10.3389/fpsyg.2017.01941.

[24] A. Frost, L.T. Hoyt, A.L. Chung, et al. (2015), "Momentary mood states measure", *APA Psyc.*, DOI: 10.1037/t48041-000.

[25] B. Alberto, P.F.M.J. Verschure (2016), "The affective slider: A digital self-assessment scale for the measurement of human emotions", *PLOS ONE*, **11(2)**, DOI: 10.1371/journal.pone.0148037.

[26] M.M. Bradley, P.J. Lang (1994), "Measuring emotion: The self-assessment manikin and the semantic differential", *Journal of Behavior Therapy and Experimental Psychiatry*, **25(1)**, pp.49-59, DOI: 10.1016/0005-7916(94)90063-9.

[27] B. Geethanjali, K. Adalarasu, A. Hemapraba, et al. (2017), "Emotion analysis using SAM (Self-assessment manikin) scale", *Biomedical Research*, **Special Issue**, pp.1-7.

[28] S. Jern, M. Pilhall, C. Jern, et al. (1991), "Short-term reproducibility of a mental arithmetic stress test", *Clinical Science*, **81(5)**, pp.593-601, DOI: 10.1042/cs0810593.

[29] Y.H. Jung, N.Y. Shin, J.H. Jang, et al. (2019), "Relationships among stress, emotional intelligence, cognitive intelligence, and cytokines", *Medicine*, **98(18)**, DOI: 10.1097/MD.0000000000015345.

[30] R.L. Ribeiro, S. Pompéia, O.F.A. Bueno (2005), "Comparison of Brazilian and American norms for the international affective picture system (IAPS)", *Rev. Bras. Psiquiatr.*, **27(3)**, pp.208-215, DOI: 10.1590/S1516-44462005000300009.

[31] S. Lodha, R. Gupta (2024), "International affective picture system (IAPS) in India: A cross-cultural validation study of highly arousing emotional pictures", *Psychology and Developing Societies*, **36(1)**, pp.52-78, DOI: 10.1177/09713336241229966.

[32] R. Atchley, R. Ellingson, D. Klee, et al. (2017), "A cognitive stressor for event-related potential studies: The Portland arithmetic stress task", *Stress*, **20(3)**, pp.277-284, DOI: 10.1080/10253890.2017.1335300.

[33] P. Karthikeyan, M. Murugappan, S. Yaacob (2012), "A study on mental arithmetic task-based human stress level classification using discrete wavelet transform", *2012 IEEE Conference on Sustainable Utilization and Development in Engineering and Technology (STUDENT)*, pp.77-81, DOI: 10.1109/STUDENT.2012.6408369.

[34] D. DeStefano, J. LeFevre (2004), "The role of working memory in mental arithmetic", *European Journal of Cognitive Psychology*, **16(3)**, pp.353-386, DOI: 10.1080/09541440244000328.

[35] T.A. Suhail, K.P. Indiradevi, E.M. Suhara, et al. (2022), "Distinguishing cognitive states using electroencephalography local activation and functional connectivity patterns", *Biomedical Signal Processing and Control*, **77**, DOI: 10.1016/j.bspc.2022.103742.

[36] S. Salvaggio, N. Masson, A. Zénon, et al. (2022), "The predictive role of eye movements in mental arithmetic", *Experimental Brain Research*, **240**, pp.1331-1340, DOI: 10.1007/s00221-022-06329-3.

[37] K.M. Lukasik, O. Waris, A. Soveri, et al. (2019), "The relationship of anxiety and stress with working memory performance in a large non-depressed sample", *Frontiers in Psychology*, **10**, DOI: 10.3389/fpsyg.2019.00004.

[38] N.P.H. Tao, A.M. Makram, P.N.Q. Khanh, et al. (2022), "Negative impact from school closures on children and parents in Vietnam during COVID-19", *The Lancet Respiratory Medicine*, **10(8)**, pp.736-738, DOI: 10.1016/S2213-2600(22)00221-1.

[39] C.D. Peltier, H. Forget, C. Blais, et al. (2017), "The effect of acute social stress on the recognition of facial expression of emotions", *Scientific Reports*, **7**, DOI: 10.1038/s41598-017-01053-3.

[40] V.L. Jentsch, C.J. Merz, O.T. Wolf (2019), "Restoring emotional stability: Cortisol effects on the neural network of cognitive emotion regulation", *Behavioural Brain Research*, **374**, DOI: 10.1016/j.bbr.2019.03.049.

[41] I. Schelhorn, S. Schlüter, K. Paintner, et al. (2022), "Emotions and emotion up-regulation during the COVID-19 pandemic in Germany", *PLOS ONE*, **17(1)**, DOI: 10.1371/journal.pone.0262283.

[42] F. Ceban, D. Nogo, I.P. Carvalho, et al. (2021), "Association between mood disorders and risk of COVID-19 infection, hospitalization, and death: A systematic review and meta-analysis", *JAMA Psychiatry*, **78(10)**, pp.1079-1091, DOI: 10.1001/jamapsychiatry.2021.1818.

[43] P.A. Hendriksen, J. Garssen, E.Y. Bijlsma, et al. (2021), "COVID-19 lockdown-related changes in mood, health and academic functioning", *European Journal of Investigation in Health, Psychology and Education*, **11(4)**, pp.1440-1461, DOI: 10.3390/ejihpe11040103.

[44] H.T. Le, A.J.X. Lai, J. Sun, et al. (2020), "Anxiety and depression among people under the nationwide partial lockdown in Vietnam", *Frontiers in Public Health*, **8**, DOI: 10.3389/fpubh.2020.589359.

[45] P.N. Ha, T.T. Nhi (2022), "Depression among students at Hanoi Medical University in the academic year 2020-2021 under COVID-19 pandemic and some related factors", *Vietnam Medical Journal*, **515(1)**, DOI: 10.51298/vmj.v515i1.2663 (in Vietnamese).