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The impact of short-term pressures on students' performances: An experimental study

Anh-Duc Hoang
EdLab Asia Educational Research and Development Centre; RMIT University: duc@edlabasia.org

We conducted an experiment to determine the impact of short-term pressure on 1,228 Grade 8 students' outcomes when performing simple math exercises. We required all students to complete 100 simple math questions for 90 seconds. We analysed students' results and then divided them into three groups: (i) a control group who did nothing; (ii) a group who performed an easy task; and (iii) a group who performed a difficult task. Finally, we required all students to solve another 100 simple math questions in 90 seconds and used a Bayesian model to compare the results of the three groups. We discovered that students who successfully solved complex tasks received higher outcomes within short periods than those who succeeded in the easy task. However, students who failed to solve either the easy or the problematic tasks received lower results than those who did nothing between the two attempts. Also, we found no differences between the results of male and female students. The findings shed further light on the Yerkes-Dodson law about the influence of stress and distress on students' performances.

Keywords: Pressure; learning outcomes; stress; experimental study

INTRODUCTION

It has been nearly nine decades since Selye's (1936) founding block of studies on stress through his experiment with rats. The impact of stress is a common research subject in the social sciences disciplines, including school, university and working environments (e.g., Hoang, 2020; Vuong, 2022). In the late 2000s, Finland received accolades for its innovative education system, which did not subject students to pressure and still acquired high PISA ranks (Kupiainen et al., 2009). However, a recent study by Vainikainen and Hautamäki (2022) reported dramatic reductions in Finnish students' performances, cognition and motivation. In particular, the learning-related beliefs index of Finnish students in 2017 was close to the 2001 index.

Vogel and Schwabe (2016) define stress as the perception of emotional or physical tension that is aware and perceived differently across individuals. Scholars list several sources of academic-related stress for students, such as examinations and assignments (de Kloet et al., 2005), extracurricular and cram school activities (McHale et al., 2012), parents' demands (Tam et al., 2018), teachers' demands (Maynard, 2001), lack of support (Yang et al., 2018) and peer pressure (Wells et al., 2009). A common belief about the impact of stress on individuals is that it enhances achievements, as expressed in the saying, 'No pressure, no diamonds'. However, there are concerns that both short-term (acute) and long-term (chronic) stress negatively influences a person's well-being (Thoits, 2010). Yerkes and Dodson (1908) propose a curvilinear relationship between eustress (positive stress) and distress (negative stress) in the Yerkes-Donson Law model. The Law suggests that low-challenging tasks with a low workload or high-challenging functions with a high workload can lead to distress. By contrast, moderate-challenging and moderate workload can cause eustress. Many studies have been conducted based on the Yerkes-Donson Law to further understand the eustress and distress phenomenon (e.g., Selye, 1950; Cooper & Payne, 1992; Nelson & Cooper, 2005; Branson et al., 2019). Rudland et al. (2020) suggested that the Yerkes and Donson conceptualization of stress may over-generalise the mechanism of stress, human learning and working activities.

The debate over the Yerkes-Donson model has extended to the debate over the effects of time pressure on stress. For instance, Carveth et al. (1996) concluded that students often perceive stress when faced with a large amount of information or tasks they must absorb or complete within a limited and inadequate time frame. However, the authors noted it was difficult to determine whether students experienced eustress or distress. Goodie & Crooks (2004) stated that time pressure could positively affect learning and that we should not consider time pressure to be a negative factor. Similarly, the American College Health Association reported that learning-related stress negatively affected 34% of undergraduate students, but 37% did not perceive stress as a factor that weakened their academic performance (Addie et al., 2022).

Several studies aligned on the benefits of stress on learning performance regardless of whether the sources of stress were within or outside the classroom environment (Vogel & Schwabe, 2016). Smeets et al. (2007) and (Schwabe et al., 2008) believed that stress at lower levels than what students regularly encounter at school might enhance students' memories. Additionally, stress can also improve an individual's brain processing efficiency (Hancock, 1989), mental function (Cahill et al., 2003), motivation (Kaiseler et al., 2009), and work performance (LeBlanc, 2009).

To capture the perspectives about prior studies on learning-related stress, on 1 December 2022, I conducted a Boolean search string in the Web of Science database (one of the largest and reputed research databases in the world (Hoang, 2022)) to published research on stress and students' learning outcomes:

TS=(eustress) OR TS =(distress) AND TI=(STUDENT) AND TI=(LEARNING)

The search string revealed 210 works published in all languages from 1960 to 2022. I excluded non-English articles, meeting abstracts, letters, retraction notes, editorial notes and book reviews and established a final dataset of 185 papers. I conducted a bibliometrics analysis, adopting all metadata to the co-occurrence analysis using the VOS Viewer software. Figure 1 presents the top 46 keywords that appeared at least five times in the dataset. Among the four clusters, the most notable topics are physical health (red) and mental health (green and yellow).

To supplement the findings of the bibliometrics analysis about knowledge structure on stress, I also conducted a chronological review of prior works on eustress and distress. As summarised in Table 1, some notable results are limited to the impacts of stress on the performance of K-12 and college students. In recent years, many empirical studies have explored this topic (e.g., Deb et al., 2014; Li et al., 2016; Prabu, 2015). The primary approach of those studies was non-experimental psychometric surveys. Apart from the inability to generalise the findings, the approaches contained measurement errors regarding differences in participants' cultural and behavioural norms 'across populations and countries (Coughlan et al., 2009).

The study reported in this paper aimed to supplement the non-experimental research findings on stress using a simple experiment capable of being replicated by other researchers across countries and contexts. By replicating this experiment in multiple contexts, scholars can quantitatively compare differences between short-term pressure and students' performances between populations.

In the next section of this paper, I explain the design of the experiment to answer the primary research question:

Does short-term pressure make students achieve better academic results?

Figure 1: Co-occurrence of keywords network from 1960 to 2022 (Minimum times of occurrences: 5; the total number of items: 46).

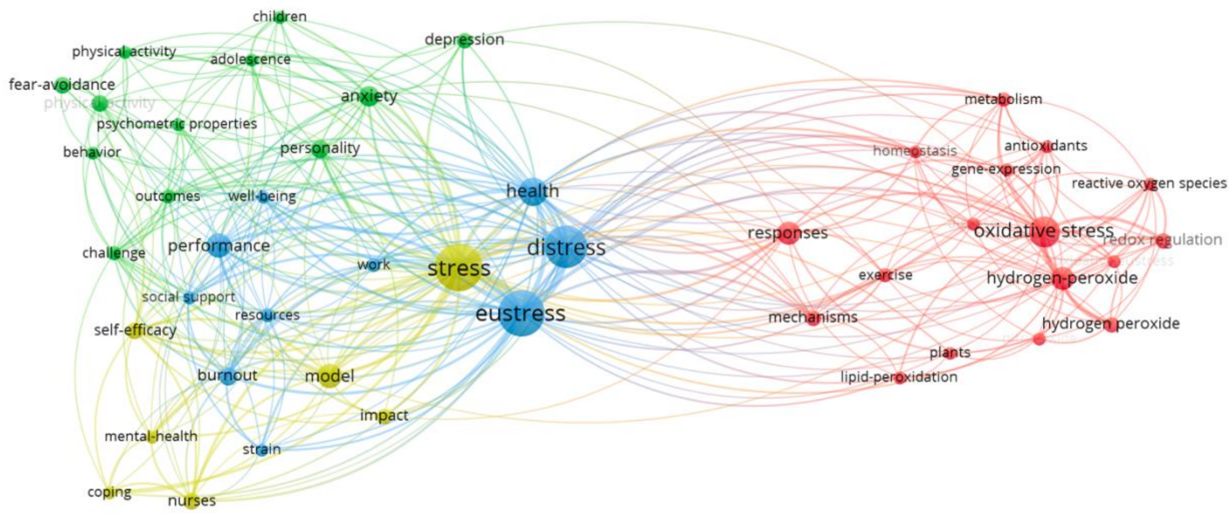


Table 1:Chronological summary of the literature on stress and student performance

No	Study	Method	Observations	Results
1	Gibbons et al. (2009)	A Transactional model survey about the source of distress and eustress	120 nursing students	Three major factors: learning and teaching, placement related and course organization
2	Busari (2012)	Survey BDI (Beck Depression Inventory)	1,200 secondary school students (600 males, 600 females)	• Stress affects students' learning outcomes • Significant difference in academic performance between genders • No significant difference in stress between genders
3	Bataineh (2013)	Survey	232 university students	• Overwhelmed workload and lack of time lead to academic stress • No significant difference in academic stress between levels of study and specialisations
4	Khan et al. (2013)	Perceived Stress Scale	150 university students	No difference in stress between genders
5	Deb et al. (2014)	Survey	400 grade 10-12 students (208 males, 192 females)	• Lower score, higher stress. • More extracurricular activities, more stress

No	Study	Method	Observations	Results
6	Prabu (2015)	Academic Stress Scale	250 upper secondary students	• Males are more stressed than females • Urban students' academic stress is higher than rural students
7	Li et al. (2016)	Correlation analyses of data from wearable devices and survey data	7 participants (5 males and 2 females) from 22 to 28 years old	• Determined a kind of eustress boost performance (accuracy of 71.33%) • Another sort of eustress that improves mood (accuracy of 57.34%)

LITERATURE REVIEW

Experimental design

This experiment aimed to examine the influence of short-term pressures on students' performances with a sample of Grade 8 students from three big cities in Vietnam. Within the scope of the experiment, participants participated in the three phases of the experiment and completed each task within a timeframe of 90 seconds. Table 2 summarises the overall structure of the experiment.

Table 2: Overview of the experiment

	Phase 1 (Task 1) (90")	Phase 2 (Task 2) (90")	Phase 3 (Task 3) (90")
Group C (control)	Solve Math Sheet 1	Do nothing	Solve Math Sheet 2
Group E (easy)		Find an easy word	
Group D (difficult)		Find a difficult word	

In the first phase, all participants completed the first task: Math Sheet 1 – a math sheet with 100 simple math equations randomly generated from https://mathsbot.com/questionGenerator with a difficulty level of 1 (see Appendix A). The ratio of four operations (addition, subtraction, multiplication, division) is equal, with 25 questions for each kind of operation. The first task required students to solve as many problems as possible within 90 seconds.

In the second phase, students in group C (control group) waited 90 seconds without a task. Students in group E (Easy) and group D (Difficult) scanned a 590 words-length document to find a word (Figure 2). The document contained the plot of *Harry Potter and the Goblet of Fire*, which I extracted from Wikipedia. Harry Potter is a famous book about the wizarding world and includes many Latin words. Therefore, students were unlikely to feel awkward when requested to find a strange expression. Students in group E needed to find the word "Veritaserum" (the name of a drink), which appears in the last paragraph of the document. This task can be solved by using regular scanning and skimming techniques. Students in group D had a more difficult task: finding "Frectbadwasai", a nonsense word constructed by the first letter of each line in the second paragraph. I chose Harry Potter as the theme for this task because the story often contains strange words, and participants would have less mistrust about the reality of the stated terms. During our pilot round with 60 students, only three found the made-up word within 90 seconds.

Regarding the last phase, all students solved Math Sheet 2, which included the same questions as Math Sheet 1 though with the order of the questions randomly shuffled to eliminate the effect of short-term memory on the result (see Appendix B).

Figure 2. The target keywords for task two

"Veritaserum" – Easy keyword for group B

Harry tells Dumbledore that Voldemort returned and is responsible for Cedric's death. Moody takes Harry back to his office to interrogate him about Voldemort, inadvertently blowing his cover when he asks Harry about a graveyard, despite Harry not mentioning a graveyard. Moody reveals that he submitted Harry's name to the Goblet of Fire and manipulated Harry to ensure he would win the tournament. Moody then attempts to kill Harry, but Dumbledore, Snape, and Minerva McGonagall subdue him. The teachers force Moody to drink Veritaserum, and he reveals that the real Moody is imprisoned in a magical trunk as his Polyjuice Potion wears off. He is revealed as Crouch Jr. and returned to Azkaban.

"Frectbadwasai" – Difficult keyword for group C

For the first task, each champion must retrieve a golden egg guarded by a dragon. Harry succeeds in retrieving his egg, which contains information about the second challenge. Shortly after, a formal dance event known as the Yule Ball takes place; Harry and Ron attend with Parvati and Padma Patil, Harry's crush Cho Chang attends with Cedric, and Hermione attends with Viktor, making Ron jealous. The second task involves the champions diving underwater to rescue someone valuable to them. Harry finishes third, but is promoted to second behind Cedric due to his "moral fibre", after saving Fleur's sister Gabrielle as well as Ron. Afterwards, Harry discovers the corpse of Crouch Sr. in the forest. While waiting for Dumbledore in his office, Harry discovers a Pensieve, which holds Dumbledore's memories. Harry witnesses a trial in which Igor Karkaroff confesses to the Ministry of Magic names of other Death Eaters after Voldemort's defeat. When he names Severus Snape, Dumbledore vouches for Snape's innocence; Snape turned spy against Voldemort before the latter's downfall. After Karkaroff names Barty Crouch Jr., a devastated Crouch Sr. imprisons his son in Azkaban. Exiting the Pensieve, Harry realizes that Crouch is the man he saw in his dream.

2.2 Data collection

The IRB approved the data collection process on Jan 2022. Thereafter, I conducted the experiment at nine schools in Hanoi, Hai Phong and Ho Chi Minh City, three major cities in Vietnam. At each school, I first discussed the experimental process with the school principal administration board to ensure the suitability for their students, including causing minimal emotional and psychological trauma to students. In each classroom, I explained the research protocol to students and teachers in charge of the relevant classes (homeroom teachers) to ensure they would not be negatively impacted by their performance during the experiment. To ensure minimal emotional impacts, I repeated two main points. First, the questions included in the experiment were primary math for Grade 3 students and were not meant to evaluate the mathematical competencies of participants (Eighth-Graders). Second, students' results would be recorded anonymously so there would not be comparisons among students.

After listening to the explanation of the activities, only students willing to attend stayed in the class. Students who did not want to spend their break time to join the experiment were invited to go out of the classroom to enjoy their break time. This arrangement ensured that ethical requirements were met and contributed to minimising distractions from non-participants. The investigators and homeroom teachers simultaneously handled the experiment handouts at randomly selected classes to ensure that students would not leak information about the experiment to other classes that might affect the results. All sessions were organised during students' long break-time sessions in the morning to eliminate the potential effects on students' pleasure caused by the cancellation of scheduled classes.

Within each class, I randomly selected 20% of students for Group C (control group), 40% for Group E (easy task), and 40% for Group D (difficult task). However, students were not told the differences among the groups or their group allocations. Table 3 summarises the descriptive statistics of the participants. The final dataset includes the results of 1,228 grade 8 students (586 male and 642 female) and is available at Harvard Dataverse (Hoang, 2022).

Table 3: Descriptive statistics

Gender		
Male	586	47.72%
Female	642	52.28%
Type of activity in task 2		
Do nothing	***266***	***21.66%***
Easy task	***477***	***38.84%***
Pass	250	*20.35%*
Fail	227	*18.49%*
Difficult task	***485***	***39.50%***
Pass	154	12.54%
Fail	331	26.96%
Total	***1,228***	***100%***

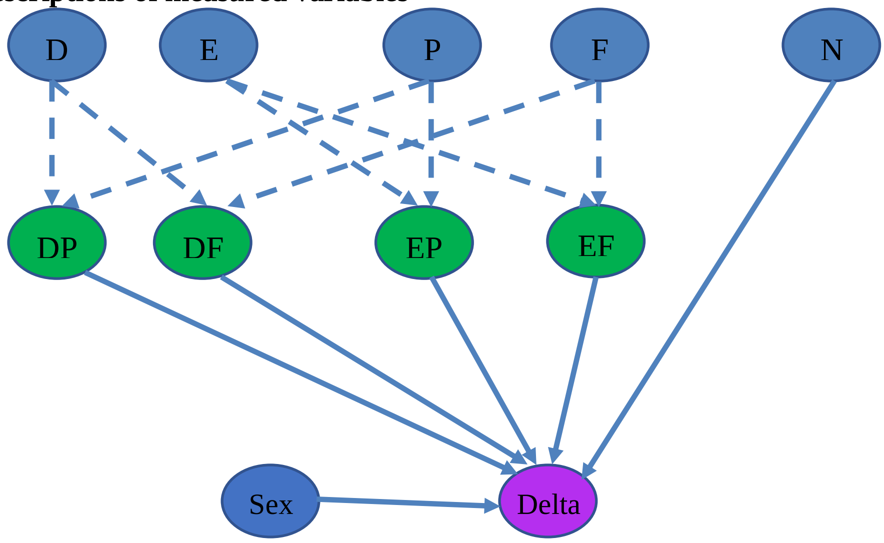
Method and variables

This study does not focus on the differences in student's abilities, which would require complex benchmarks and indicators, especially when comparing the results of students from different cultures. Rather than comparing the absolute value of derivatives in mathematical tasks among participants, I primarily considered the gap between each participant's performance on task one and task three. Table 4 includes a description of the variables measured in this study.

While regular analyses such as ANOVA, Kruskal-Wallis's test, and Dunn's test can compare differences between parametric and non-parametric variables, they are limited within a single-level of demographics, for instance, result differences among sub-groups such as genders, grade levels, etc. Scholars have designed various Bayesian models to examine random effects on students' academic performance (Arreola & Wilson, 2020; Cabras & Tena Horrillo, 2016). I formed a multi-level varying intercept model to examine the impact of short-term pressures on students' performances in various sequences between different tasks (Figure 3). I adopted this model from the Bayesian Mindsponge Framework (BMF) (Vuong & Napier, 2015; Vuong, 2023), developed to support a complexity in a theoretical model in social science research (Nguyen et al., 2022). In the field of educational psychology, the framework has been adopted to explore the sense of connectedness and the behaviour of help-seeking (Nguyen et al., 2021). The BMF approach also allows researchers to imply simulations based on the actual results of small numbers of observations within each sub-group. The validations of simulations also ensure higher generalisability. To perform the BMF, this study adopted the bayesvl package 0.8.5 in R software, version 3.6.3, developed by Vuong et al. (2020).

Figure 3: The primary model

Table 4: Descriptions of measured variables



Code	Definition of variables
Sex	A binomial variable determines whether the participant is a male (1) or a female (0).
C	A binomial variable determines whether the participant belongs to the control group (1) or not (0).
E	A binomial variable determines whether the participant belongs to group E, which must find the easy word in task 2 (1) or not (0).
D	A binomial variable determines whether the participant belongs to group D, which must find the problematic word in task 2 (1) or not (0).
P	A binomial variable determines whether the participant found the word in task 2 (1) or not (0).
F	A binomial variable determines whether the participant failed task 2 (1) or not (0).
N	A binomial variable determines whether the participant do nothing in task 2 (1) or not (0).
DP	A binomial variable determines whether the participant passed the difficult task in task 2 (1) or not (0).
DF	A binomial variable determines whether the participant failed the difficult task in task 2 (1) or not (0).
EP	A binomial variable determines whether the participant passed the easy task in task 2 (1) or not (0).
EF	A binomial variable determines whether the participant failed the easy task in task 2 (1) or not (0).
Delta	Numerical value, the subtraction of the participant's result in task 3 and task 1.

Appendix C contains the R code used to perform the analysis. Figure 2 illustrates the primary model for evaluating short-term pressure’s impact on student's performance. Blue nodes present the original observations, while green nodes represent transformed variables. For instance, if the participant must find the problematic word in task two and complete the task within 90 seconds, that result will be presented by a green node "DP". The overall mathematical formulation of this model can be expressed as:

Delta ~ b_E_and_P_Delta * E*P + b_E_and_F_Delta * E*F + b_D_and_P_Delta * D*P + b_D_and_F_Delta * D*F + b_N_Delta * N + a_SEX[SEX]

Model validation

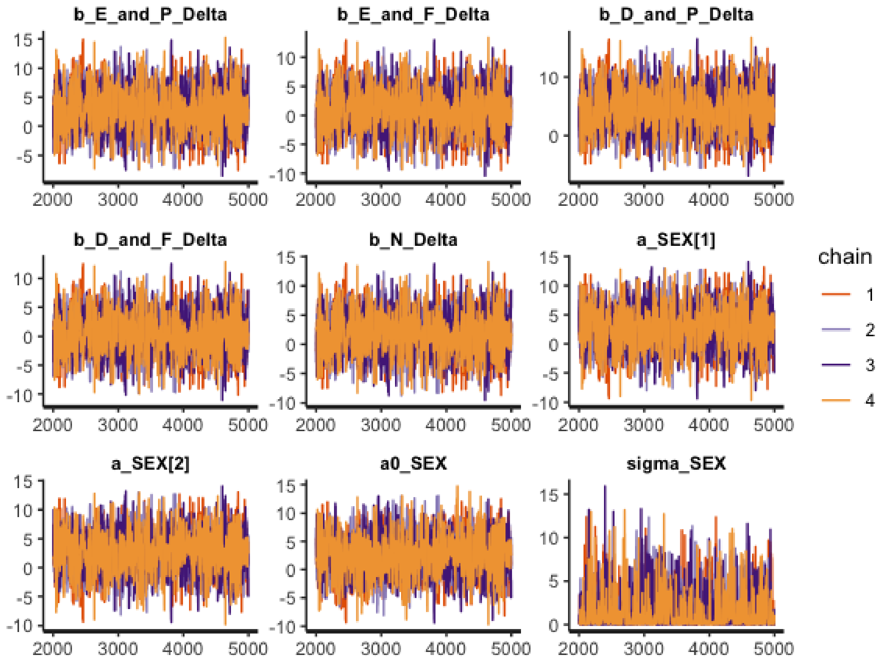
Table 5 presents the results of the Markov Chain Monte Carlo (MCMC) simulation regarding the posterior distributions. I performed 4 MCMC chains, with 5,000 steps for each (including 2000 warmup draws and 3000 post-warmup draws). According to Brooks & Gelman (1998), the model can be validated as an adequate sample size (n_eff) bigger than 1000 independent samples and Rhat of 1, which shows the convergence of Markov links to the target distribution. In addition, Figure 4 presents the stability of four MCMC chains, in which the only sign of abnormal dissociation belongs to the participants' gender. Though the coefficients of a_SEX[1] (2.70) and a_SEX[2] (2.65) are close, which means there is no difference in change of students' outcomes regarding genders. Therefore, I excluded students' gender in the further interpretation of this research. To supplement the n_eff and Rhat, the Gelman Shrink factor test (Gelman & Rubin, 1992) shows rapid convergences to 1.0 in most simulations (Appendix D). Also, except for the variable Sex, the distributions of all coefficients satisfy the technical requirement at 89% HPDI (Highest Posterior Distribution Intervals), see Appendix E.

Table 5. Results of posteriors distribution, using Markov Chain Monte Carlo simulation for the model of short-term pressure on student performance

4 chains, each with iter=5000; warmup=2000; thin=1;
post-warmup draws per chain=3000, total post-warmup draws=12000.

	mean	se_mean	sd	2.5%	25%	50%	75%	97.5%	n_eff	Rhat
b_E_and_P_Delta	2.85	0.08	3.34	-3.70	0.65	2.82	4.98	9.66	1640	1
b_E_and_F_Delta	0.91	0.08	3.34	-5.61	-1.29	0.88	3.05	7.73	1639	1
b_D_and_P_Delta	4.46	0.08	3.34	-2.09	2.27	4.43	6.61	11.28	1639	1
b_D_and_F_Delta	0.41	0.08	3.34	-6.12	-1.78	0.40	2.55	7.22	1639	1
b_N_Delta	1.71	0.08	3.34	-4.84	-0.49	1.68	3.85	8.52	1640	1
a_SEX[1]	2.70	0.08	3.34	-4.09	0.56	2.73	4.90	9.25	1639	1
a_SEX[2]	2.65	0.08	3.34	-4.16	0.52	2.67	4.85	9.20	1639	1
a0_SEX	2.53	0.09	3.39	-4.26	0.34	2.60	4.76	9.20	1592	1
sigma_SEX	1.16	0.06	1.75	0.01	0.11	0.42	1.41	6.42	1005	1

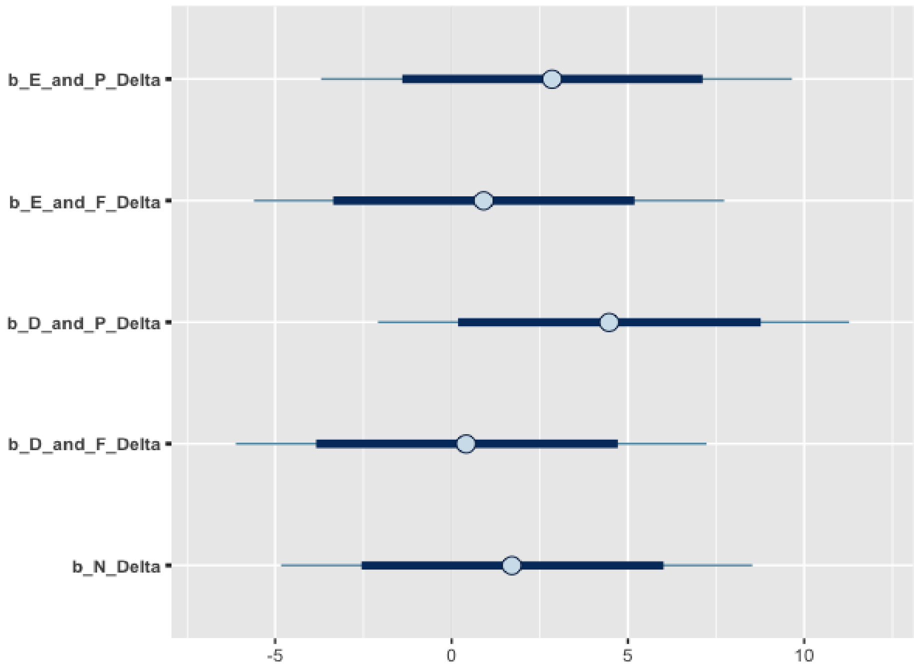
Figure 4: Results of MCMC chains for Bayesian Model of Short-term Pressure over Student Performance



RESULTS

Overall, the results show that all students achieved better results in task three than in task one. Also, there is no significant difference between the changes in outcomes for male and female students regarding the mean of 2.70 and 2.65 in Delta. There is an increase in students' performance in group C (control group), with a mean of 1.71 (Table 5), when considering the regular difference in results between task one and task three.

Figure 5. Means of students' changes between task 1 and task 3 across three groups



Group C students are those who had no task two. Smith et al. (2016) proposed that the intensity of stress on an individual's memory during the retrieval process depends on the strength of their memory. Their study stated that right after an individual experiences stress, there are both rapid and short, and gradual and long-lasting hormonal changes. Those changes deter the memory-strengthening processes. Therefore, as students in the control group were not involved in any stressful activities during task two, they did not face any chemical changes that hampered their memory. The control group's better-achieved results in task three might also result from the momentum they built by completing task one. That is, the students were familiar with how to perform the exercise and implemented short-term retrieval practices (Kuhlmann, 2005).

To answer the research question: *Does short-term pressure make students achieve better academic results?* I examined the changes in students from groups E and D. On the one hand, students in both groups performed better when they passed the challenge in task two. However, students involved in the problematic quest tended to have higher increments (mean of 4.46) than their peers who took the easier ones (mean of 2.85). This phenomenon complements the hypothetical model of Rudland et al. (2020) that stress can be good for learning. Whenever students are put into a difficult situation and can conquer the challenges, specific increments of endogenous factors inside their brains boost their working memory and help them attain higher achievements (McEwen, 2008).

On the other hand, students in groups E and D performed lower than the control group if they failed to find their words in task two, regardless of the difficulties of the challenges. In particular, the mean changes in the results of students who failed to find the easy and challenging words were 0.91 and 0.41, respectively. Those results are lower than the mean of changes in the control group's results (1.71). Ackerman & Gross (2003) discussed a similar issue in their study about negative emotions caused by perceived time pressure and time deprivation. However, more investigations are needed to explain the declining results of students who failed the easy task in step two. For instance, besides the influence of short-term pressure, students' short-term performance might be impacted by students' characteristics (Astuti & Pusparini, 2020), moods (Aniţei et al., 2013), motivations and engagement in activities (Papamitsiou et al., 2014).

CONCLUSION

The findings from this study strengthened the Yerkes & Dodson (1908) model concerning eustress and distress. Even though the same source of factors can cause various manifestations of stress and effects in different individuals (Selye, 1975), stress has certain roles in improving students' academic outcomes. My experiment showed that those students who found either the easy word or the problematic made-up word in task two performed better in task three; however, students who failed to find either the easy or the problematic word experienced worse results in task three compared to the control group. Therefore, it is not necessary to put students under extreme pressure situations. The notation of individualised and personalised learning should be extended beyond the customisation of students' questions, lessons and performance to include rounded perspectives about students' well-being. The accumulation of such short-term challenges at the proper levels will significantly contribute to the incremental learning of students (Jaeger & Adair, 2017). Oducado and Estoque (2021) showed that elevated stress levels can result in diminished learning, adaptation and memory retention, impacting cognitive functions such as focus, problem-solving and memory recall. In addition, stress can lead to diminished self-worth, challenges in managing circumstances, sleep disturbances, less focus and irregular eating habits, all of which can affect academic performance and personal development (Kötter et al., 2017). Tibus & Ledesma (2021) also examined the correlation between stress and academic performance and emphasised the necessity of readily available stress management techniques to mitigate the adverse effects on students' learning and achievement.

Curriculum and instructional designers must consider an individual student's capacity, proficiency and traits to achieve a harmonious advancement in mental and cognitive growth. It is crucial to incorporate such distinct attributes to design challenges that align with the individual student's zone of proximal development through incremental changes in the complexity of learning activities (Groot et al., 2020). The findings of this study show that short-term pressure is only one factor among several that contribute to supporting students' well-rounded growth. In addition to the minor adjustments teachers can make in their classes, this research also suggests that school leaders and policymakers should revisit their measuring and evaluation policies and regulations to promote students' holistic development. It is unnecessary to create unanticipated pressure on students, notably via over-favoured-deadlock-questions. Instead, greater emphasis should be placed on cultivating students' competencies.

Finally, this study's findings contrast with the work of Prabu (2015), who claimed that male students perceive more stress than female students, and the study by Busari (2012), who found that male students perform better under pressure than female students. Similar to the finding of Khan et al. (2013), this study suggests that the influences of short-term pressure on male and female students are the same.

However, several limitations of this study should be addressed. First, the randomly selected students are eighth graders from public schools in big cities in Vietnam. They do not include rural students or students from bi-lingual and international schools. However, the results reflect Vietnamese school culture, in which students are familiar with various short-term pressures (blitz quizzes, oral exams, etc.) (Hoang et al., 2020). Second, it is evident that students with higher reading proficiency in English will have more chances to complete task two. T the control variable did not include differences in students' English capabilities. Third, as the difficult word in task two had been built on collecting letters vertically, it might be more difficult for ordinary readers and easier for dyslexic readers. Within this study's scope, I could not manage this difference. Finally, the experiment is designed to only measure the changes in simple math exercises, which does not represent the ability to capture students' overall academic performance (Nichols et al., 2012).

Concerning extending the impacts and implications of studies about stress and students' performance, I have several suggestions for future studies. First, I recommend that researchers worldwide duplicate this study to complement the differences in national and school cultures. Second, future studies should extend the control variables to minimise the research design's subjectivities and diversify the perspectives to compare different groups of students. For instance, various music and/or sounds can be used as distractions to measure students' focus across all experiment phases. Primarily, I encourage scholars to develop high stakes testing experiments to examine different effects on students' overall academic competencies. Last but not least, I strongly recommend researchers replicate the experiment with participants from more comprehensive ranges of ages and specialisations.

REFERENCES

Ackerman, D. S., & Gross, B. L. (2003). Is time pressure all bad? Measuring the relationship between free time availability and student performance and perceptions. *Marketing Education Review*, *13*(2), 21–32. https://doi.org/10.1080/10528008.2003.11488825

Addie N., Merians, Mischel, E., Frazier, P., & Lust, K. (2022). Relationships between childhood adversity and life functioning in US college students: Risk and resilience. *Journal of American College Health*, 1–11. https://doi.org/10.1080/07448481.2021.2024205

Aniţei, M., Chraif, M., & Liliana, M. (2013). Influence of fatigue on impulsiveness, aspiration level, performance motivation and frustration tolerance among young Romanian psychology students. *Procedia - Social and Behavioral Sciences*, *78,* 630–634. https://doi.org/10.1016/j.sbspro.2013.04.365

Arreola, E. V., & Wilson, J. R. (2020). Bayesian multiple membership multiple classification logistic regression model on student performance with random effects in university instructors and majors. *PLOS ONE*, *15*(1), e0227343. https://doi.org/10.1371/journal.pone.0227343

Astuti, E. S., & Pusparini, I. (2020). Video making task to decrease anxiety in students' speaking performance. *Journey (Journal of English Language and Pedagogy), 3*(1), 52–56. https://doi.org/10.33503/journey.v3i1.705

Bataineh, M. Z. (2013). Academic stress among undergraduate students: The case of education faculty at King Saud University. *International interdisciplinary journal of education*. *1*(1033), 1–7.

Branson, V., Dry, M. J., Palmer, E., & Turnbull, D. (2019). The Adolescent Distress-Eustress Scale: Development and validation. *SAGE Open*, *9*(3), 215824401986580. https://doi.org/10.1177/2158244019865802

Brooks, S. P., & Gelman, A. (1998). General methods for monitoring convergence of iterative simulations. *Journal of Computational and Graphical Statistics*, *7*(4), 434–455. https://doi.org/10.1080/10618600.1998.10474787

Busari, A. O. (2012). Evaluating the relationship between gender, age, depression and academic performance among adolescents. *Scholarly Journal of Education*, *1*(1), 6–12.

Cabras, S., & Tena Horrillo, J. de D. (2016). A Bayesian non-parametric modeling to estimate student response to ICT investment. *Journal of Applied Statistics*, *43*(14), 2627–2642. https://doi.org/10.1080/02664763.2016.1142946

Cahill, L., Gorski, L., & Le, K. (2003). Enhanced human memory consolidation with post-learning stress: Interaction with the degree of arousal at encoding. *Learning & Memory*, *10*(4), 270–274. https://doi.org/10.1101/lm.62403

Carveth, J. A., Gesse, T., & Moss, N. (1996). Survival strategies for nurse-midwifery students. *Journal of Nurse-Midwifery*, *41*(1), 50–54. https://doi.org/10.1016/0091-2182(95)00072-0

Cooper, C. L., & Payne, R. L. (1992). International perspectives on research into work, well-being, and stress management. In *Stress & well-being at work: Assessments and interventions for occupational mental health.* (pp. 348–368). American Psychological Association. https://doi.org/10.1037/10116-023

Coughlan, M., Cronin, P., & Ryan, F. (2009). Survey research: Process and limitations. *International Journal of Therapy and Rehabilitation*, *16*(1), 9–15. https://doi.org/10.12968/ijtr.2009.16.1.37935

de Kloet, E. R., Joëls, M., & Holsboer, F. (2005). Stress and the brain: From adaptation to disease. *Nature Reviews Neuroscience*, *6*(6), 463–475. https://doi.org/10.1038/nrn1683

Deb, S., Strodl, E., & Sun, J. (2014). Academic-related stress among private secondary school students in India. *Asian Education and Development Studies*, *3*(2), 118–134. https://doi.org/10.1108/AEDS-02-2013-0007

Gelman, A., & Rubin, D. B. (1992). Inference from iterative simulation using multiple sequences. *Statistical Science*, *7*(4). https://doi.org/10.1214/ss/1177011136

Gibbons, C., Dempster, M., & Moutray, M. (2009). Surveying nursing students on their sources of stress: A validation study. *Nurse Education Today*, *29*(8), 867–872. https://doi.org/10.1016/j.nedt.2009.04.008

Goodie, A. S., & Crooks, C. L. (2004). Time-pressure effects on performance in a base-rate task. *The Journal of General Psychology*, *131*(1), 18–28. https://doi.org/10.3200/GENP.131.1.18-28

Groot, F., Jonker, G., Rinia, M., ten Cate, O., & Hoff, R. G. (2020). Simulation at the frontier of the zone of proximal development: A test in acute care for inexperienced learners. *Academic Medicine*, *95*(7), 1098–1105. https://doi.org/10.1097/ACM.0000000000003265

Hancock, P. A. (1989). A dynamic model of stress and sustained attention. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *31*(5), 519–537. https://doi.org/10.1177/001872088903100503

Hoang, A.-D. (2020). Pandemic and teacher retention: Empirical evidence from expat teachers in Southeast Asia during COVID-19. *International Journal of Sociology and Social Policy*, *40*(9/10), 1141–1166. https://doi.org/10.1108/IJSSP-07-2020-0269

Hoang, A.-D. (2022). *Replication data for: Impact of short-term pressure on student's performance: An Experimental Study* (Harvard Dataverse, V1). https://doi.org/10.7910/DVN/SKSDLZ

Hoang, A.-D. (2023). A bibliometrics analysis of research on teachers' satisfaction from 1956 to 2022. *International Journal of Educational Management*, *37*(1), 164–185. https://doi.org/10.1108/IJEM-01-2022-0009

Hoang, A.-D., Pham, H.-H., Nguyen, Y.-C., Nguyen, L.-K.-N., Vuong, Q.-H., Dam, M. Q., Tran, T., & Nguyen, T.-T. (2020). Introducing a tool to gauge curriculum quality under Sustainable Development Goal 4: The case of primary schools in Vietnam. *International Review of Education*, *66*(4), 457–485. https://doi.org/10.1007/s11159-020-09850-1

Jaeger, M., & Adair, D. (2017). Time pressure in scenario-based online construction safety quizzes and its effect on students' performance. *European Journal of Engineering Education*, *42*(3), 241–251. https://doi.org/10.1080/03043797.2016.1153042

Kaiseler, M., Polman, R., & Nicholls, A. (2009). Mental toughness, stress, stress appraisal, coping and coping effectiveness in sport. *Personality and Individual Differences*, *47*(7), 728–733. https://doi.org/10.1016/j.paid.2009.06.012

Khan, M. J., Altaf, S., & Kausar, H. (2013). Effect of perceived academic stress on students' performance. *FWU Journal of Social Sciences*, *7*(2).

Kötter, T., Wagner, J., Brüheim, L., & Voltmer, E. (2017). Perceived medical school stress of undergraduate medical students predicts academic performance: An observational study. *BMC Medical Education*, *17*(1), 256. https://doi.org/10.1186/s12909-017-1091-0

Kuhlmann, S. (2005). Impaired memory retrieval after psychosocial stress in healthy young men. *Journal of Neuroscience*, *25*(11), 2977–2982. https://doi.org/10.1523/JNEUROSCI.5139-04.2005

Kupiainen, S., Hautamäki, J., & Karjalainen, T. (2009). *The Finnish education system and PISA*. opetus-ja kulttuuriministeriö.

LeBlanc, V. R. (2009). The effects of acute stress on performance: Implications for health professions education. *Academic Medicine*, *84*(Supplement), S25–S33. https://doi.org/10.1097/ACM.0b013e3181b37b8f

Li, C.-T., Cao, J., & Li, T. M. H. (2016). Eustress or distress. *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct*, 1209–1217. https://doi.org/10.1145/2968219.2968309

Maynard, T. (2001). The student teacher and the school community of practice: A consideration of 'learning as participation'. *Cambridge Journal of Education*, *31*(1), 39–52. https://doi.org/10.1080/03057640123915

McEwen, B. S. (2008). Central effects of stress hormones in health and disease: Understanding the protective and damaging effects of stress and stress mediators. *European Journal of Pharmacology*, *583*(2–3), 174–185. https://doi.org/10.1016/j.ejphar.2007.11.071

McHale, S. M., Blocklin, M. K., Walter, K. N., Davis, K. D., Almeida, D. M., & Klein, L. C. (2012). The role of daily activities in youths' stress physiology. *Journal of Adolescent Health*, *51*(6), 623–628. https://doi.org/10.1016/j.jadohealth.2012.03.016

Nelson, D., & Cooper, C. (2005). Stress and health: A positive direction. *Stress and Health*, *21*(2), 73–75. https://doi.org/10.1002/smi.1053

Nguyen, M.-H., La, V.-P., Le, T.-T., & Vuong, Q.-H. (2022). Introduction to Bayesian Mindsponge Framework analytics: An innovative method for social and psychological research. *MethodsX*, *9*, 101808. https://doi.org/10.1016/j.mex.2022.101808

Nguyen, M.-H., Le, T.-T., Nguyen, H.-K. T., Ho, M.-T., Nguyen, H. T. T., & Vuong, Q.-H. (2021). Alice in Suicideland: Exploring the suicidal ideation mechanism through the sense of connectedness and help-seeking behaviors. *International Journal of Environmental Research and Public Health*, *18*(7), 3681. https://doi.org/10.3390/ijerph18073681

Nichols, S., Glass, G., & Berliner, D. (2012). High-stakes testing and student achievement: Updated analyses with NAEP data. *Education Policy Analysis Archives*, *20*, 20. https://doi.org/10.14507/epaa.v20n20.2012

Oducado, R. M. F., & Estoque, H. (2021). Online learning in nursing education during the COVID-19 Pandemic: Stress, satisfaction, and academic performance. *Journal Of Nursing Practice*, *4*(2), 143–153. https://doi.org/10.30994/jnp.v4i2.128

Papamitsiou, Z. K., Terzis, V., & Economides, A. A. (2014). Temporal learning analytics for computer-based testing. *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge*, 31–35. https://doi.org/10.1145/2567574.2567609

Prabu, P. S. (2015). A study on academic stress among higher secondary students. *International Journal of Humanities and Social Science Invention*, *4*(10), 63–68.

Rudland, J. R., Golding, C., & Wilkinson, T. J. (2020). The stress paradox: How stress can be good for learning. *Medical Education*, *54*(1), 40–45. https://doi.org/10.1111/medu.13830

Schwabe, L., Bohringer, A., Chatterjee, M., & Schachinger, H. (2008). Effects of pre-learning stress on memory for neutral, positive and negative words: Different roles of cortisol and autonomic arousal. *Neurobiology of Learning and Memory*, *90*(1), 44–53. https://doi.org/10.1016/j.nlm.2008.02.002

Selye, H. (1936). A syndrome produced by diverse nocuous agents. *Nature*, *138*(3479), 32–32. https://doi.org/10.1038/138032a0

Selye, H. (1950). Stress and the general adaptation syndrome. *BMJ*, *1*(4667), 1383–1392. https://doi.org/10.1136/bmj.1.4667.1383

Selye, H. (1975). Confusion and controversy in the stress field. *Journal of Human Stress*, *1*(2), 37–44. https://doi.org/10.1080/0097840X.1975.9940406

Smeets, T., Giesbrecht, T., Jelicic, M., & Merckelbach, H. (2007). Context-dependent enhancement of declarative memory performance following acute psychosocial stress. *Biological Psychology*, *76*(1–2), 116–123. https://doi.org/10.1016/j.biopsycho.2007.07.001

Smith, A. M., Floerke, V. A., & Thomas, A. K. (2016). Retrieval practice protects memory against acute stress. *Science*, *354*(6315), 1046–1048. https://doi.org/10.1126/science.aah5067

Tam, H., Kwok, S. Y. C. L., Ling, C. C. Y., & Li, C. I. (2018). The moderating effects of positive psychological strengths on the relationship between tiger parenting and child anxiety. *Children and Youth Services Review*, *94*, 207–215. https://doi.org/10.1016/j.childyouth.2018.10.012

Thoits, P. A. (2010). Stress and health: Major findings and policy implications. *Journal of Health and Social Behavior*, *51*(1_suppl), S41–S53. https://doi.org/10.1177/0022146510383499

Tibus, E. D., & Ledesma, S. K. G. (2021). Factors of academic stress: Do they impact English academic performance? *International Journal of Evaluation and Research in Education (IJERE)*, *10*(4), 1446. https://doi.org/10.11591/ijere.v10i4.21296

Vainikainen, M.-P., & Hautamäki, J. (2022). Three studies on learning to learn in Finland: Anti-Flynn effects 2001–2017. *Scandinavian Journal of Educational Research*, *66*(1), 43–58. https://doi.org/10.1080/00313831.2020.1833240

Vogel, S., & Schwabe, L. (2016). Learning and memory under stress: Implications for the classroom. *Npj Science of Learning*, *1*(1), 16011. https://doi.org/10.1038/npjscilearn.2016.11

Vuong, Q.-H. (2023). *Mindsponge theory*. Walter De Gruyter GmbH.

Vuong, Q.-H., La, V.-P., Nguyen, M.-H., Ho, M.-T., Tran, T., & Ho, M.-T. (2020). Bayesian analysis for social data: A step-by-step protocol and interpretation. *MethodsX*, *7*, 100924. https://doi.org/10.1016/j.mex.2020.100924

Vuong, Q. H. (Ed.). (2022). *A new theory of serendipity: Nature, emergence and mechanism*. Walter De Gruyter GmbH.

Vuong, Q. H., & Napier, N. K. (2015). Acculturation and global mindsponge: An emerging market perspective. *International Journal of Intercultural Relations*, *49*, 354–367. https://doi.org/10.1016/j.ijintrel.2015.06.003

Wells, S. J., Merritt, L. M., & Briggs, H. E. (2009). Bias, racism and evidence-based practice: The case for more focused development of the child welfare evidence base. *Children and Youth Services Review*, *31*(11), 1160–1171. https://doi.org/10.1016/j.childyouth.2009.09.002

Yang, M.-Y., Harmeyer, E., Chen, Z., & Lofaso, B. M. (2018). Predictors of early elementary school suspension by gender: A longitudinal multilevel analysis. *Children and Youth Services Review*, *93*, 331–338. https://doi.org/10.1016/j.childyouth.2018.08.008

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit formation. *Journal of Comparative Neurology & Psychology*.

APPENDICES

Appendix A. Math sheet 1

TASK 1 – SOLVE AS MUCH AS YOU CAN WITHIN 90 SECONDS

Name: **Score:**

11 + 27 =	9 + 35 =	42 + 26 =	14 + 22 =
45 – 16 =	93 – 17 =	54 – 18 =	52 – 24 =
73 x 6 =	9 x 81 =	24 x 5 =	33 x 4 =
14 ÷ 2 =	48 ÷ 8 =	42 ÷ 6 =	54 ÷ 9 =
14 + 18 =	21 + 4 =	23 + 48 =	31 + 29 =
86 – 14 =	67 – 17 =	84 – 26 =	56 – 18 =
7 x 96 =	87 x 5 =	23 x 5 =	16 x 6 =
10 ÷ 5 =	72 ÷ 9 =	64 ÷ 8 =	55 ÷ 5 =
5 + 77 =	9 + 35 =	45 + 46 =	23 + 58 =
69 – 7 =	35 – 12 =	57 – 16 =	82 – 27 =
55 x 2 =	8 x 32 =	26 x 3 =	32 x 4 =
9 ÷ 3 =	24 ÷ 3 =	60 ÷ 12 =	84 ÷ 7 =
12 + 83 =	79 + 12 =	24 + 31 =	29 + 32 =
96 – 18 =	82 – 16 =	72 – 36 =	56 – 24 =
16 x 3 =	9 x 16 =	14 x 6 =	17 x 3 =
24 ÷ 3 =	36 ÷ 4 =	84 ÷ 4 =	72 ÷ 4 =
67 + 14 =	27 + 12 =	52 + 39 =	63 + 48 =
75 - 19 =	28 – 12 =	99 – 42 =	86 – 27 =
46 x 4 =	4 x 30 =	19 x 3 =	23 x 5 =
16 ÷ 4 =	49 ÷ 7 =	78 ÷ 6 =	82 ÷ 2 =
24 + 88 =	22 + 39 =	34 + 48 =	46 + 73 =
39 – 15 =	65 – 14 =	65 – 28 =	72 – 46 =
7 x 77 =	70 x 8 =	32 x 4 =	43 x 5 =
20 ÷ 5 =	81 ÷ 9 =	69 ÷ 3 =	72 ÷ 3 =
7+ 75 =	85 – 16 =	19 x 5 =	85 ÷ 5 =

Appendix B. Math sheet 2

TASK 3 – SOLVE AS MUCH AS YOU CAN WITHIN 90 SECONDS

Name: **Score:**

42 + 26 =	14 + 22 =	9 + 35 =	11 + 27 =
24 + 31 =	29 + 32 =	79 + 12 =	12 + 83 =
72 – 36 =	56 – 24 =	82 – 16 =	96 – 18 =
14 x 6 =	17 x 3 =	9 x 16 =	16 x 3 =
23 + 48 =	31 + 29 =	21 + 4 =	14 + 18 =
84 ÷ 4 =	72 ÷ 4 =	36 ÷ 4 =	24 ÷ 3 =
52 + 39 =	63 + 48 =	27 + 12 =	67 + 14 =
45 + 46 =	23 + 58 =	9 + 35 =	5 + 77 =
34 + 48 =	46 + 73 =	22 + 39 =	24 + 88 =
65 – 28 =	72 – 46 =	65 – 14 =	39 – 15 =
26 x 3 =	32 x 4 =	8 x 32 =	55 x 2 =
60 ÷ 12 =	84 ÷ 7 =	24 ÷ 3 =	9 ÷ 3 =
84 – 26 =	56 – 18 =	67 – 17 =	86 – 14 =
23 x 5 =	16 x 6 =	87 x 5 =	7 x 96 =
78 ÷ 6 =	82 ÷ 2 =	49 ÷ 7 =	16 ÷ 4 =
42 ÷ 6 =	54 ÷ 9 =	48 ÷ 8 =	14 ÷ 2 =
32 x 4 =	43 x 5 =	70 x 8 =	7 x 77 =
19 x 3 =	23 x 5 =	4 x 30 =	46 x 4 =
57 – 16 =	82 – 27 =	35 – 12 =	69 – 7 =
99 – 42 =	86 – 27 =	28 – 12 =	75 - 19 =
24 x 5 =	33 x 4 =	9 x 81 =	73 x 6 =
64 ÷ 8 =	55 ÷ 5 =	72 ÷ 9 =	10 ÷ 5 =
54 – 18 =	52 – 24 =	93 – 17 =	45 – 16 =
69 ÷ 3 =	72 ÷ 3 =	81 ÷ 9 =	20 ÷ 5 =
19 x 5 =	85 ÷ 5 =	85 – 16 =	7+ 75 =

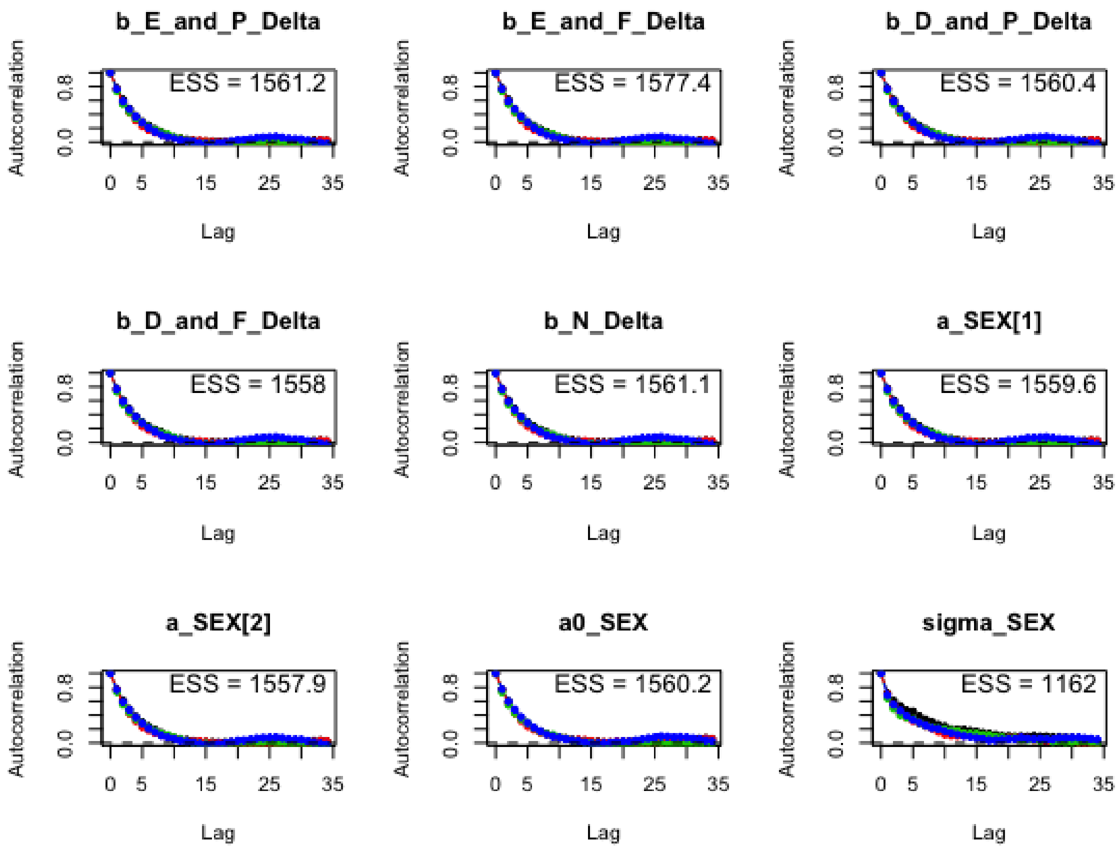
Appendix C. R code

```
library(readxl)
library(dplyr)
library(ggplot2)
library(reshape2)
library("bayesvl")
library("rstan")

model1=read.csv(file = "Pressure1200.csv",header = T)

model1[colSums(!is.na(model1)) > 0]

#1Design the model
model <- bayesvl()
model <- bvl_addNode(model,"E","binom")
model <- bvl_addNode(model,"D","binom")
model <- bvl_addNode(model,"N","binom")
model <- bvl_addNode(model,"P","binom")
model <- bvl_addNode(model,"F","binom")
model <- bvl_addNode(model,"Delta","norm")
model <- bvl_addNode(model,"SEX","binom")

#2 Create trans variables and
model <- bvl_addNode(model,"E_and_P","trans")
model <- bvl_addNode(model,"E_and_F","trans")
model <- bvl_addNode(model,"D_and_P","trans")
model <- bvl_addNode(model,"D_and_F","trans")

#3 Define the relationship of transforming data
model <- bvl_addArc(model,"E", "E_and_P","*")
model <- bvl_addArc(model,"P", "E_and_P","*")

model <- bvl_addArc(model,"E", "E_and_F","*")
model <- bvl_addArc(model,"F", "E_and_F","*")

model <- bvl_addArc(model,"D", "D_and_P","*")
model <- bvl_addArc(model,"P", "D_and_P","*")

model <- bvl_addArc(model,"D", "D_and_F","*")
model <- bvl_addArc(model,"F", "D_and_F","*")

#4 Regression between transformed data
model <- bvl_addArc(model,"E_and_P","Delta","slope")
model <- bvl_addArc(model,"E_and_F","Delta","slope")
model <- bvl_addArc(model,"D_and_P","Delta","slope")
model <- bvl_addArc(model,"D_and_F","Delta","slope")
model <- bvl_addArc(model,"N","Delta","slope")

#4b Varying intercepts regression for additional variable
model                                                                    <-
bvl_addArc(model,"SEX","Delta","varint",priors=c("a0_~normal(0,5)","sigma_~normal(0,5)"))
```

```
#5 Network print to test logical connection
bvl_bnPlot(model)

#Step 6 Logical check
summary(model)

#Step 7 Stan code
model_string <- bvl_model2Stan(model)
cat(model_string)

#Step 8 Stan model
bvl_stanPriors(model)

#Step 9 Model evaluation
bvl_bnScore(model,model1)

bvl_bnStrength(model,model1)

#Step 10 MCMC modeling
model <- bvl_modelFit(model, model1, warmup = 2000, iter = 5000, chains = 4, cores = 4)

#warmup 3000 iter 8000

summary(model)

#Step 11 MCMC plot
bvl_plotTrace(model)

#Step 12 Gelman Shrink factors test
bvl_plotGelmans(model, NULL, 3, 3)

#(model, NULL, No of row, No of col)

#Step 13 Autocorrelation check
bvl_plotAcfs(model,NULL,3,3)

#Step 14 Model overall evaluation
bvl_plotIntervals(model)
bvl_plotParams(model,3,3)
bvl_plotIntervals(model,c("b_E_and_P_Delta", "b_E_and_F_Delta"))
bvl_plotIntervals(model,c("b_D_and_P_Delta", "b_D_and_F_Delta"))
bvl_plotIntervals(model,c("b_E_and_P_Delta", "b_E_and_F_Delta", "b_D_and_P_Delta",
"b_D_and_F_Delta", "b_N_Delta"))

#Step 15 Posteriors distribution

bvl_plotDensity(model,c("b_E_and_P_Delta", "b_E_and_F_Delta", "b_D_and_P_Delta",
"b_D_and_F_Delta", "b_N_Delta"))
```

```
#Step 16 Coupling comparison

bvl_plotDensity2d(model,"b_E_and_P_Delta", "b_E_and_F_Delta", color_scheme="blue")
bvl_plotDensity2d(model,"b_D_and_P_Delta", "b_D_and_F_Delta", color_scheme="blue")

bvl_plotDensity2d(model,"b_E_and_P_Delta", "b_D_and_P_Delta", color_scheme="green")
bvl_plotDensity2d(model,"b_E_and_F_Delta", "b_D_and_F_Delta", color_scheme="red")

bvl_plotDensity2d(model,"b_E_and_F_Delta", "b_N_Delta", color_scheme="orange")
bvl_plotDensity2d(model,"b_D_and_F_Delta", "b_N_Delta", color_scheme=" orange")

bvl_plotDensity2d(model,"b_E_and_P_Delta", "b_N_Delta", color_scheme="navy")
bvl_plotDensity2d(model,"b_D_and_P_Delta", "b_N_Delta", color_scheme="navy")
```

Appendix D. Results of the Gelman Shrink Factor Test



Appendix E. HPDI