Gadjah Mada Journal of Psychology, Volume 8, Number 2, 2022: (page 150-164)
E-ISSN 2407-7798
https://jurnal.ugm.ac.id/gamajop
DOI: 10.22146/gamajop.72911

Science Majoring Background Modulates the Psychological Responses to Stress on Numerical Task

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Submitted 9 February 2022 **Accepted 21 July 2022** **Published 28 Oktober 2022**

Abstract. Numerical tasks have become part of the daily activities of individuals even in academic potential tests which have the potential to cause stress to individuals. The background of majoring in science is thought to be one of the factors that influence the individual's physiological response to stress when doing numerical tasks. This study aims to investigate whether there are differences in the final results and processing stages on numerical tasks between students majoring in science and social studies. A simple mathematical numerical task was given to participants to respond by adding numbers that were close to each other within a predetermined time limit. Twenty-two participants took the test twice with a one-week gap between tests. Recording of participants' electrodermal activity while working on a task using a galvanic meter. The results show that there is no difference in performance between students majoring in social science and science *($t = 0.552$; $p = 0.587$)*. However, there are indications of different stress dynamics, where students majoring in science show a positive effect of stress, while students majoring in social science show the opposite. Further discussed the stress response on the difference in the frequency of meetings with numerical tasks during education at school.

Keywords: academic background; numeric task; skin conductance response; stress

Every day individuals are never separated from numerical tasks, such as calculating how many minutes it takes to arrive at the campus on time from home which usually takes 15 minutes if it is smooth and 30 minutes if it is jammed. Also, how much change for food for 75 thousand rupiahs if we pay with one hundred thousand rupiahs. In addition, some scholastic aptitude test tools also require completion of simple numerical tasks. This means that numerical assignment situations will always exist in an individual's life. It is common knowledge that students studying natural sciences are accustomed to dealing with numerical tasks more frequently than students in social sciences. This is thought to be additional capital for individuals to deal with future numerical assignment situations, both in simple mathematics (such as addition, subtraction, etc) and mathematics in general (such as algebra, arithmetic, etc).

The popular belief that students who take natural science majors tend to have better mathematical ability than those who take a social science major requires further validation. Hence, past literature suggested that students who were originally majoring in social sciences experienced anxiety when taking courses involving numerical calculations such as mathematics or statistics (Townsend et al., 1998; Zeidner, 1991). Social science students typically have negative attitudes toward complex mathematical operations since it requires a more effortful cognitive process that does not favor their inherent thinking

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style (Murtonen & Lehtinen, 2003). However, it is unknown whether these students will also face obstacles by doing basic numerical calculations (e.g., addition, subtraction, etc).

Natural science students have a major advantage compared to social science major students when it comes to performing numerical tasks. They got more exposure to such tasks, as the nature of their study requires them to solve complex mathematical problems. Therefore, they have more time to learn, practice, and increase their numerical calculation ability through habit. A study by Benavides-Varela et al. (2016) showed that the frequency of engaging in numerical activities correlates to individual calculating skills. In other words, more practice and habit equals mastery, as the human brain has the capability to learn through repetitive practice (Green & Bavelier, 2008; Zhan et al., 2018; Maier et al., 2019). Hence, the possibility that science major students have better performance in basic numerical calculation is quite high.

On the other hand, mathematical calculation skills seem to be optional for social science students. When it comes to conducting research, social science students can choose whether they are going to use quantitative or qualitative methods. However, it seems that qualitative research has already become a tradition in social science fields (Jankowski & Wester, 2002). In the US and Finland for instance, there is even a negative attitude towards quantitative methods among social science students, which was related to less appreciation and difficulty to learn quantitative methods (Murtonen & Lehtinen, 2003). Moreover, social science research tends to highly value "novelty" over developing prior knowledge through test and re-test mechanisms (i.e., quantitative methods), which makes exploratory strategy (i.e., qualitative methods) more important (Jaffe, 2014). As a result, it is surprising that much social science research is rarely cited (Jaffe, 2014) and the "mathematical culture" seems to be not as strong as natural science studies. Social science student is less exposed to complex mathematical tasks, although it might not necessarily mean that they are bad at basic numeric skills.

In general, any task that involves numerical stimuli requires two kinds of approaches (McCloskey et al., 1985), namely: a numeric-processing system and a calculation system. The numeric-processing system involves a process to understand numbers (number-comprehension system) and to create numbers (number-production system). On the other hand, the calculation system involves simple mathematical operations that involve addition, subtraction, multiplication, and other more complicated formulas. There are several tasks that involve both numeric-processing system and numeric-calculation system, however, there are also tasks that require only numeric-processing system such as the memory task (Fazio et al., 2014; Peters & Bjalkebring, 2015; van Opstal & Verguts, 2011). In memory tasks, participants typically are asked to recognize numbers without specifically carrying out mathematical operations. On the other hand, a task which involves both numeric-processing and numeric-calculation requires participants to recognize the numbers and to conduct mathematical operations such as in the Kraepelin Test (Kraepelin & Robetson, 1919).

Kraepelin Test is a psychological test that consists of numerical stimuli (Kraepelin & Robetson, 1919) for evaluating individual work performance. In this test, participants are instructed to do simple mathematical calculations in a very limited time. This particular test has been later found to be able to cause stress (Shimbo et al., 2004), as its demand for precision and speed when doing this task will give rise to heightened stress levels (Pieters & van der Ven, 1982). Participants who did the Kraepelin test demonstrated an increase in blood glucose level (Shimbo et al., 2004) as a predictor of cognitive distress (Benton, 2002; Sim et al., 2010).

The phenomenon of stress (or distress) refers to non-specific physical responses due to unprecedented stimuli or occurrences (Selye, 1936). The physical symptoms can include constipation, hyperventilation, migraine headaches, tension muscles, and heart palpitations (Herman & Lester, 1994). In addition, stress is often accompanied by a subjective feeling of powerlessness as a result that a person's inherent resources available are not enough to cope with the demands caused by the stimuli (Giota & Gustafsson, 2017).

In general, stress can be perceived as either negative (i.e., distress) or positive (i.e., eustress) (Selye, 1936; O'Sullivan, 2011; Aschbacher et al., 2013). There are a number of studies that showed that a high level of stress can impair individual performance. For instance, those who showed symptoms of anxiety and high levels of stress have a higher risk of having poor academic performance (Sohail, 2013; Grøtan et al., 2019). Further, stress will trigger the body's alarm system and activate sympathetic nervous systems which alter the transient biological conditions such as electrodermal activities (Posada-Quintero et al., 2018). When the stress is prolonged, it can cause depression and affect the body's immunity system (Leonard, 2000; Reiche et al., 2004; Cañas-González et al., 2020). However, we have to take note that this is not always the case. Among athletes, for example, certain levels of stress are indeed required for higher performance (Harmison, 2011). In a later case, stress is perceived more positively, i.e., as a fuel for better performance.

In this current study, we seek to investigate whether educational background (social science versus natural science) would produce differential results and processing stages on the numerical task that involves a simple numeric-calculation system. The finding would answer whether there are differences when two scientific backgrounds (natural science and social science) experience similar stress stimulation. Since there is a popular belief that students from natural science majors tend to have better mathematical ability than those who were from social science, it was predicted that they would have less stress than social science students. To do this we created a tool that changed dynamically based on the quality of their answer by presenting a numeric stimulus and asking the participants to calculate it. It also tested our participants' twice to see whether they are getting better with time. Participants' physiological response was also recorded using stress meter tools that we also developed.

Methods

Participants

This study recruited 24 people for our study. This number was determined based on the previous study (Sugimoto et al., 2009) which also used less than 20 participants for their study. Moreover, we also perform a priori analysis to make sure that our number of participants has sufficient statistical power. We used Cohen's (1988) classification for the effect size. By considering the (ϱ = .50) effect size with (1 - β) at .80 and α at .05 level, we conclude that 21 participants were required to get sufficient statistical strength.

To minimize the extraneous variables which may interfere with our data, we only recruited males as our participants. This decision was made since we have a concern that menstrual cycles may influence stress and emotional processes (Goi et al., 2007) during the Kraepelin task. A study by Sugimoto et al. (2009), which used female-only participants, found that the Kraepelin task does not cause any effect on their stress levels after they check participants' biological parameters through their saliva. However, they did not control the menstrual cycle of their subjects. Past works of literature have found that the menstrual cycle can influence emotional informational processing (Farage et al., 2008) and the emotional state (Kirschbaum et al., 1999; Liening et al., 2010) of the female participant. Therefore, when it comes to using females as the subject of study, this aspect should be taken into account since it might affect the overall data. It is not clear whether the numeric task that they give to their participants really fails to induce the stress level, or whether this failure is caused by the menstrual cycle that interferes with their data.

All of the participants in our study are university students who are either natural science or social science majors. This consideration was made since previous literature (Zeidner, 1991) indicates that students from social science tend to show anxiety during a test that involved a numerical calculation (i.e., statistics). Therefore, we assume that the analysis for each group (social and science students) should be separated. We also perform further screening of our participants using DSM V Self-Rated Level 1 Cross-Cutting Symptom Measure Adult scale (Meaklim et al., 2018) to ensure that none of them have any psychiatric diagnosis (i.e., depression or anxiety) which can possibly interfere with their emotional physiological response.

From the total of 24 participants, we exclude two people from our study, leaving 22 participants for our study. We perform this process due to their performance on our cognitive is way too high. This indicates that there is a possibility that these two participants might already be familiar with our numeric task, therefore they do not fit with our research criteria.

Procedure

This is an experimental study to investigate the differences between two scientific backgrounds in responding to numerical tasks that are designed as a stressor. The method

of experimental study is one shot study towards twice intake with the following research procedure.

Firstly, we recruited our participants through the cross-faculty online broadcast system at Universitas Gadjah Mada. We perform this process to ensure that the participant's requirement can be met (see Participants). In the online recruitment forms, the potential participant was asked to answer a set of questions which was designed to obtain data on their past experiences regarding their involvement as participants in any other psychological testing. Only those who reported that they never take a numeric test, such as Kraepelin or Pauli test, will be invited to the next step.

The potential participants then were asked to fill out the DSM V Self-Rated Level 1 Cross-Cutting Symptom Measure Adult scale. Those who did not show any psychiatric diagnosis are allowed to continue the further processes. Next, the potential participants were asked to report their demographic backgrounds by answering a set of questions on our form. The first twelve science major students and the first twelve participants with a social science major will automatically become the participants in our study.

Secondly, all of the participants who are already being screened will be asked to be involved in our first data-gathering processes at the Mind, Brain, and Behavior Laboratory, Universitas Gadjah Mada. All of them will be involved in our first cognitive test intake. This process is performed with the help of our research assistant in a soundproof room. During their cognitive test intake, their physiological response will be recorded using a stress meter.

Thirdly, the participant will be asked to come to our laboratory again a week after the first cognitive test. We decide to perform the second cognitive task intake a week after the first test since previous literature suggested that the verbal stimulus will be forgotten after a week interval (Wickelgren, 1972). The learning effect is one of the threats that can possibly contaminate our data. Therefore, a week interval is required to ensure the validity of this research.

Instrument

We measured the behavioral, physiological, and subjective perceptions of our participants using a set of tools that we developed. The behavioral measurement will be performed using our cognitive task tools. The participants will be asked to do the basic calculations from a set of numbers that we developed as a cognitive numeric stimulus, on the computer program which will be presented in a very short interval with a limited time. This cognitive test was developed based on the Kraepelin and Pauli test by the Mind, Brain, and Behavior Laboratory with several differences.

In the Kraepelin and Pauli test, the numeric stimulus is statics. In the other words, the next number that the participants should calculate is not determined based on their previous answer. In our cognitive test, on the other hand, the numeric stimulus was set using a computer algorithm. The upcoming numeric stimulus presented that should be

calculated by the participants will always change dynamically based on the quality of the answer given by the participants on the previous stimulus. The quality of the answer will be judged based on how fast they calculate the number and the accuracy of their answers. If the participants' answers are good, their next stimulus will gradually be harder, and so does the opposite.

For physiological response, electrodermal activity was measured using stress-psychoanalyzer measurement tools which were developed by the Sensor and Telecontrol Systems Laboratory, Nuclear and Physical Engineering Department, Universitas Gadjah Mada, and Amakusa Instrumentation Technology. This tool is developed based on skin conductance response (SCR) measurement that was already generally used on galvanometers in the previous literature (i.e., Nock & Mendez, 2008). This SCR reaction is related to the activation of the autonomic-sympathetic nervous system (Boucsein, 2012; Andrianome et al., 2017). Therefore, increased activity on SCR indicates that the individuals may experience an increased level of stress (Christopoulos et al., 2019).

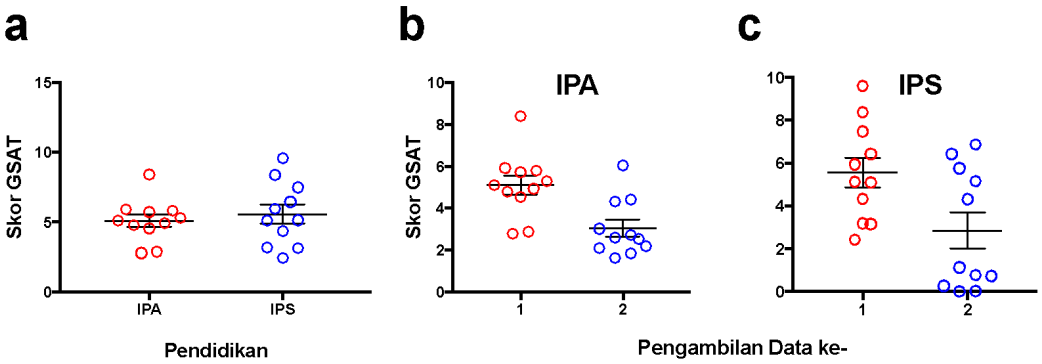
Participants' subjective perceptions of stress in this study were measured by filling out the DSM V Self-Rated Level 1 Cross-Cutting Symptom Measure Adult scale (Meaklim et al., 2018). This self-rated scale consists of 23 questions which were designed to measure 13 individuals' psychiatric disorder symptoms such as depression, anger, mania, anxiety, somatic symptoms, suicidal ideation, psychosis, sleep problems, memory, repetitive thoughts and behaviors, dissociation, personality functioning, and substance use. Each item will ask about how often they experienced the specific symptoms during the past two weeks. For example, "*Merasa lebih sering jengkel, menggerutu, atau marah, daripada biasanya?*" and "*Kurang berminat dalam melakukan aktivitas?*". There are five options that they can choose to answer these questions (0 = none; 1 = slight, less than a day or two; 2 = mild, several days; 3 = moderate, nearly every day; 4 = severe, nearly every day). Participants who gave an answer higher than 2 on any of the psychiatric symptoms will be excluded, except for substance use, psychosis, and suicidal ideation will be removed if they give an answer higher than 1.

Results

Overall, this study found that there is no significant difference between participants from science and social science majors on their cognitive task performance on the first cognitive test *($t = 0.552$; $p = 0.587$)* as shown in Figure 1a. This shows that academic background does not determine an individual ability to calculate numeric stimulus, which is usually found on cognitive tests. This is, however, contradictory to the general assumption that people from science majors tend to be better at calculating basic numeric stimulus than those who are from a social science major as our cognitive test data indicates the opposite pattern.

Figure 1.

The Participants' Cognitive Test Score Based On Their Academic Background

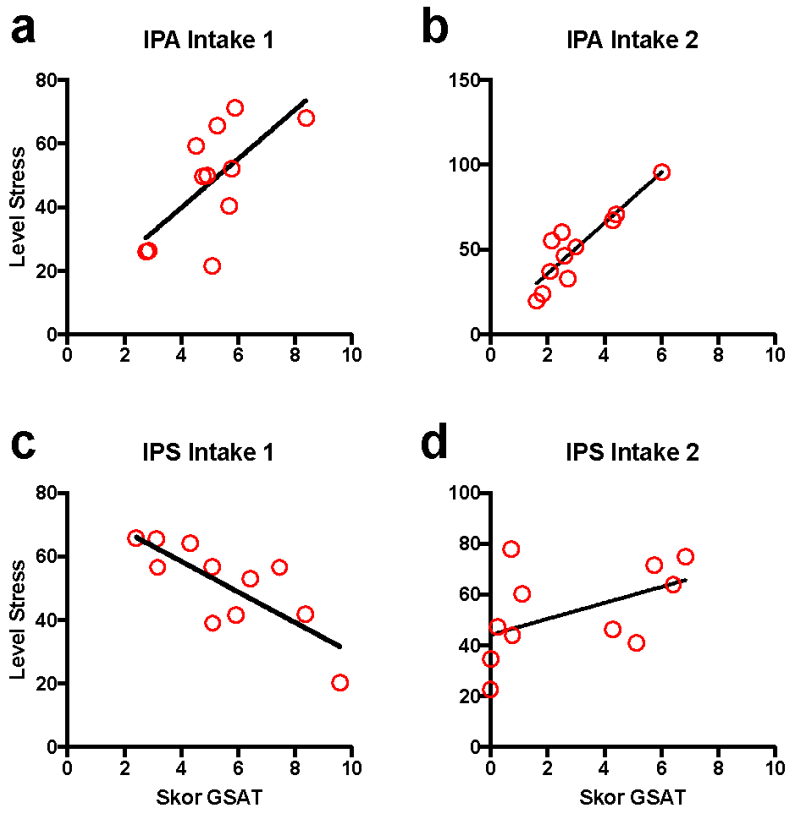


Although the average mean score for participants from social science major *(M* = 5.552*; Figure 1c)* is a bit higher than those who are from the science major *(M* = 5.096*;* Figure 1b*)*, the score variation for participants from social science major *(SEM* = 0.6871*)* is also higher than those who are from the science background *(SEM* = 0.4595*).* This indicates that participants from social science majors have wider variability in basic calculation ability than those participants with a science major.

Next, further analysis was carried out to check whether there was a correlation between the first and second data collection. Overall, it was found that there was a correlation between participants' performance on the numerical task and the level of stress we measured using the stress meter. For the participants from science majors, the correlation between numeric task performance and stress level was observed in the first intake (r = 0.664; p = 0.026; Figure 2a). This correlation was even stronger in the second intake (r = 0.898; p = 0.001; Figure 2b). This pattern implies that participants who showed a higher level of stress will tend to perform better at the numeric task. As the participants learned the task, their performance started to become much better, which was shown in their measurement results on the second intake.

Figure 2.

The Correlation Between Participants' Cognitive Test Score and Their Stress Level



This study found some interesting patterns in our social science participants' data. As seen in Figure 2c, there is a negative correlation between participants' numeric task performance and the level of stress (r = 0.780; p = 0.005) in the first data intake. This pattern is the exact opposite of what was observed in our participants with a science major. The higher their stress level, the lower their numeric task performance. On the other hand, the data on the second data intake shows a different pattern. As seen in Figure 2d, there is a positive correlation tendency between the numeric task performance and stress levels, although the data shows that the correlation is not significant (r = 0.494; p = 0.120).

Discussion

Overall, this study found that educational background does not influence individual performance on basic numeric calculation tasks. In other words, both social major and social science major students show similar performance on the cognitive test. There are some possible explanations for why this pattern might occur. First, past literature suggested that people who study social science majors tend to have analytical and logical-mathematical thinking styles, while those who learned social science majors tend to have synthetical and verbal-linguistic thinking styles (Kuhn, 1962). Both

logical-mathematical and verbal-linguistic thinking styles have a contribution to individuals' basic numeric calculation ability (Irawan & Kencanawati, 2016). A study by Sukadji (1993) has found that logical-mathematical thinking has an influence on how fast the numeric task can be finished, while verbal-linguistic thinking contributes to the accuracy of the numeric task. The non-significant difference between participants from the science major and the social science major was due to each cognitive component contributing to an individual's cognitive task performance. Participants from the science majors were eminent at how fast they can finish the task while participants from the social science majors were eminent at their answer accuracy. As a result, their overall performance shows no significant difference.

Although the overall numeric task performance between people from science and social science majors was insignificant, the dynamic of stress levels seems to show a different pattern. Among participants with a science major, a high physiological response towards stress was followed by better performance on the cognitive task. On the other hand, the pattern that was observed among participants with social science backgrounds is the opposite. This shows that academic background may be related to how the physiological response to stress may influence individual performance on cognitive tasks.

The positive correlation between the level of stress and the cognitive test performance among science major participants indicates that the stress level does not always restrain individual performance on numeric tasks. This is what is called eustress, a type of stress that the person experiencing it interprets as "positive" (O'Sullivan, 2011). On the other hand, our major social science participants showed the opposite pattern, in which the correlation between stress levels and individual cognitive test performance was negative. This is called distress, a type of stress that negatively affects individual performance (Selye, 1974). There is a possibility that this different pattern regarding how stress influences participants' numeric-task performance was shaped by the nature of their academic learning. Those who learn science subjects tend to be exposed more to numeric-related assignments than those who learn social science. As a result, they adapt easier. Past literature supports this claim, which found that the field area of study will influence how comfortable a person is in doing a numeric-related task (Zeidner, 1991).

The results of this experimental study indicate that the physiological response to stress can affect individual performance in two different ways, positive and negative. This includes other contexts, for example, in the work environment, and in sports. Past literature has found that employee perception of stress in the office influences how they will regulate their stress (Le Fevre et al., 2003). On the other hand, a study among athletes shows that a certain level of stress is required to induce athletes' optimum performance (Harmison, 2011). These two findings indicate that the psychological aspect of stress (i.e., individual perception toward a stressor) needs to be considered when we want to understand the relation between the physiological response of stress (i.e., electrodermal activity) and certain observable behavior. Further research is required in order to

investigate the role of psychological aspects (e.g., personality, working style, etc.) to understand the dynamics of stress in an individual.

Conclusion

In conclusion, there is no difference in cognitive performance between science and social studies students in doing simple numerical tasks. The assumption that science students benefited more on numerical tests than social studies students were not proven. So far, the objectivity of the examination process for scholastic aptitude tests or psychological tests using numerical tasks has a scientific argument that the educational background of the test takers does not affect the individual's response to the stimulus. In fact, there are indications that social studies students have a wider variability in basic arithmetic abilities than science students. This experiment also found that numerical tasks were seen as a positive stressor, considering that after knowing the assignment order, the participants became more familiar with the assignment and had problem-solving patterns.

The research team realized that this research needed development, both in terms of the experimental method and the selection of the test stimulus. In the future, research needs to explore more stimuli in psychological tests (in addition to numerical numbers, there are also word stimuli, image stimuli, etc.) in order to provide more additional information regarding the objectivity of tests based on empirical evidence from scientific research.

Recommendation

This study and findings are very relevant for readers who are looking for information related to studies on whether numerical task exposure has the potential to cause stress in individuals with different educational backgrounds. This study informs the reader about the interrelationship of numeric-based learning factors and the psychological processes that arise later in response to numerical tasks, such as psychometric examinations. Therefore, the implications of this study are very close to everyday learning life, especially in answering the question that indeed learning that exposes the use of numerical tasks is at least enough to provide learning for students to cope with strategies to manage stress on numerical assignments positively.

Declaration

Acknowledgments

This research was carried out in collaboration with the research team of Mind Brain and Behavior Laboratory, Faculty of Psychology UGM, along with several laboratory assistant students, on behalf of Samudera Fadlilla Jamaluddin. Also, Galang Lufityanto was the person in charge of MBB Lab for permission to use experimental equipment.

Authors' contributions

IY and SPA designed the study and made the analysis. IY wrote the manuscript assisted by AVC who was tasked with searching for relevant literature. GL as a liaison for the provision of facilities in the laboratory.

Funding

This research was funded by the Faculty of Psychology Universitas Gadjah Mada's Grant in 2018, contract number 2062/SD/PL.03.02/V/2018.

Conflict of Interest

There is no potential conflict of interest on this research

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