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ASSESSING THE CONNECTION BETWEEN STRESS AND IMPULSIVITY IN A MATHEMATICAL SETTING

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Abstract - *This study investigates whether differences in cognitive processing between highly impulsive and slightly impulsive individuals during challenging tasks are attributed to an involuntary stress response rather than being solely a personality trait. Participants were categorized based on impulsivity scores, and cardiovascular responses (blood pressure and heart rate) were monitored before, during, and after performing mathematical tasks. Results indicate significant systolic blood pressure variation in non-impulsive individuals (P = 0.0001) compared to the insignificant variation in the impulsive group (P = 0.72). Moreover, less impulsive individuals showed a 24% increase in heart rate during the task, while more impulsive individuals only had an 11% increase. These findings suggest that lower impulsivity may lead to a heightened stress response, highlighting innate differences in how impulsive and non-impulsive individuals unconsciously handle difficulty. The study implies potential links between stress, biological reactions, and cognitive processes in adolescents.*

INTRODUCTION

This study explores the relationship between innate impulsivity and cardiovascular activity, specifically the activation of the sympathetic nervous system during mathematical problem-solving. In light of increasing awareness and accommodation for diverse learning abilities and personalities, there is a growing recognition that impulsivity-related challenges in academics extend beyond ADHD. These struggles impact academic performance and interest in STEM fields, contributing to a decline in the participation of intelligent individuals in impactful areas (Marriott et al., 2019). Numerous studies establish an inverse relationship between impulsivity and academic performance, hindering students from excelling and contributing to positive change. Additionally, research suggests a correlation between impulsivity and heart rate and blood pressure, with highly impulsive individuals exhibiting a lower rate of heart rate increase (Allen et al., 2019). However, uncertainties remain, and some studies propose that the context of situations, particularly in adolescents, significantly influences impulsivity (Lorenz and Kray, 2019). The interplay between impulsivity, cardiovascular activity, and stress adds complexity to the understanding of academic performance. Impulsive individuals may experience lower stress levels during testing scenarios, potentially explaining their poorer academic performance due to reduced heart rate spikes. This research aims to establish the relationships among test-taking scenarios, cardiovascular activity, and impulsivity, shedding light on the inherent, unconscious differences in students' exam performance.

The hypothesis posits that cardiovascular activity differs among varying levels of impulsive individuals during academic, mathematical tasks. It suggests that highly impulsive individuals exhibit significantly higher or more active resting cardiovascular activity compared to their less impulsive peers. While performing calculations, both groups may display similar cardiovascular responses, with the less impulsive group experiencing a more pronounced increase in activity compared to the more impulsive group.

METHODOLOGY

Materials used in the study include a participant information document, an online survey to collect email addresses and impulsivity levels measured using BIS-11 scores, a set of 30 algebra problems printed on 10 one-sided copies, a timer, an adult supervisor, spare pencils, and a systolic blood pressure/heart rate monitor (BP/HRM). Systolic blood pressure levels are specifically chosen as they strongly correlate with mental state and stress levels, and for brevity, are referred to as "blood pressure" or "BP."

The sampling procedure involved 60 students from Tesla STEM High School enrolled in Algebra 2 across two class periods. Participants received an informed consent form outlining the research motives and methodology. Following this, participants took the BIS-11 impulsivity quiz and submitted their scores through a survey.

In the correlational procedure, participants with BIS-11 percentiles above the 80th and below the 20th were randomly selected, resulting in ten participants for the secondary study. These participants were connected to a BP/HRM and seated at a desk. They began with two minutes of controlled breathing with closed eyes, during which BP/HR was measured at 0:00 and 1:00. Participants then worked on algebra problems, with BP/HR measured every two minutes for 10 minutes (2:00, 4:00, 6:00, 8:00, 10:00). After completing the task, BP/HR was measured at 12:00 and 13:00 during controlled breathing. The session concluded at 14:00, including the disconnection from the BP/HRM.

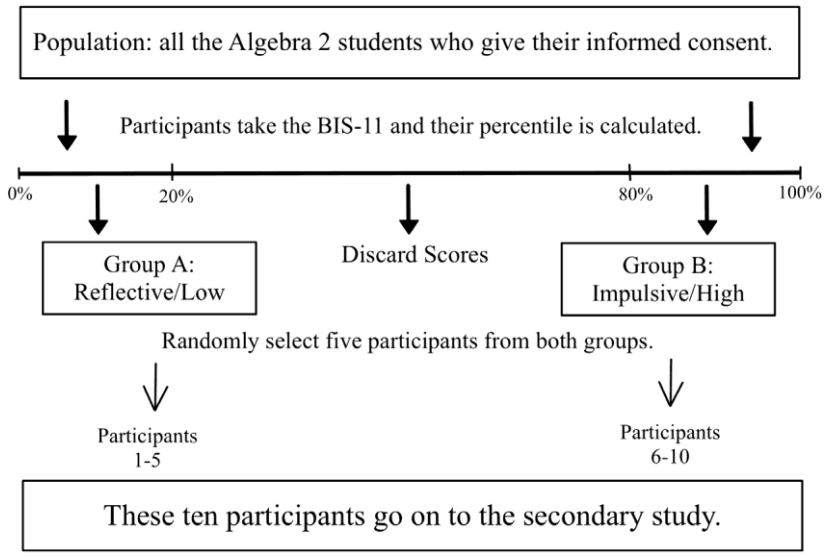


Figure 1. Flowchart of how the ten participants were selected.

Table 1. Average heart rate (BPM) for both the low and high impulsivity groups, separated by their cognitive states.

Impulsivity Group	Heart Rate While Resting (Prior to Task)[1]	Heart Rate While Active (Performing Task)[2] (BPM)	Heart Rate While Resting (After Task)[3] (BPM)
Low	65.13	80.55	73.38
High	77.50	86.73	81.67

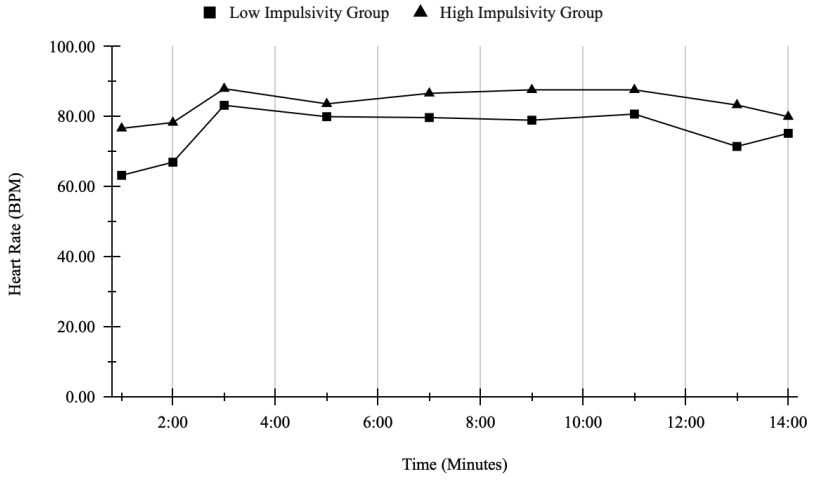
[1] Minute 0:00 to 1:59; a state of focused, deep breathing, prior to being given the problems.
[2] Minute 2:00 to 11:59; a state of computation and mathematical processing. Stress is expected to be seen here.
[3] Minute 12:00 to 14:00; a state of focused, deep breathing, after completing the problems and/or the timer running out.

Table 2. Average systolic blood pressure (mmHg) for both the low and high impulsivity groups, separated by their cognitive states.

Impulsivity Group	Systolic Blood Pressure While Resting (Prior to Task)	Systolic Blood Pressure While Active (Performing Task)	Systolic Blood Pressure While Resting (After Task)
Low	99.88	107.55	96.00
High	113.50	113.27	110.17

Data Analysis

Results were visualized in two ways: heart rate/blood pressure over numerical time (Fig. 2) and heart rate/blood pressure over categorical time intervals (Fig. 3). Once again, diastolic blood pressure levels were not collected (or analyzed) due to their relative ineffectiveness at predicting stress levels or state of mind. The graphs of heart rate and blood pressure over (numerical) time (Fig. 2) showed a considerable spike at minute 2:00 and a general dip around minute 12:00. The expected results, which were (1) that highly impulsive individuals would have higher resting heart rate/blood pressure levels and (2) that the less impulsive group would exhibit a greater relative increase in heart rate at the beginning of the task period, were successfully exhibited in the data collected. There is also an evident difference between the heart rates/blood pressures of the low and high impulsivity groups' heart rates during the pre-task period, although this difference appears to shrink in the during task period and increases only slightly during the post-task period (Fig. 3); this trend was also hypothesized. Other quantifiable results were determined after further data analysis.



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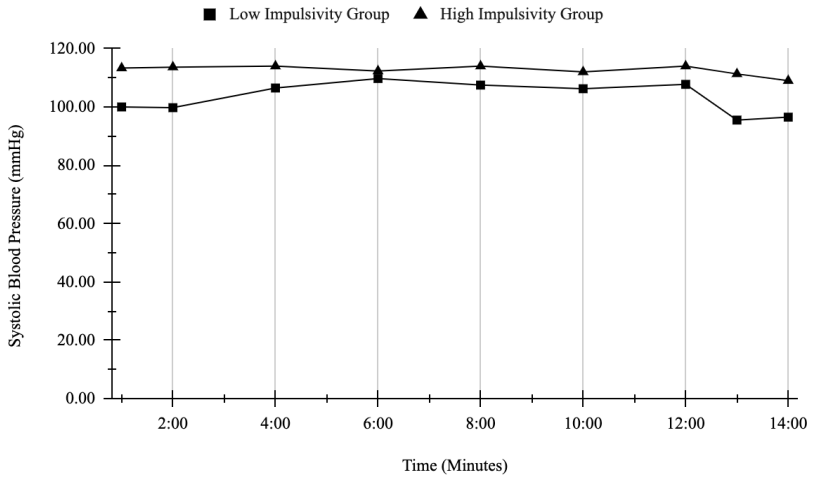

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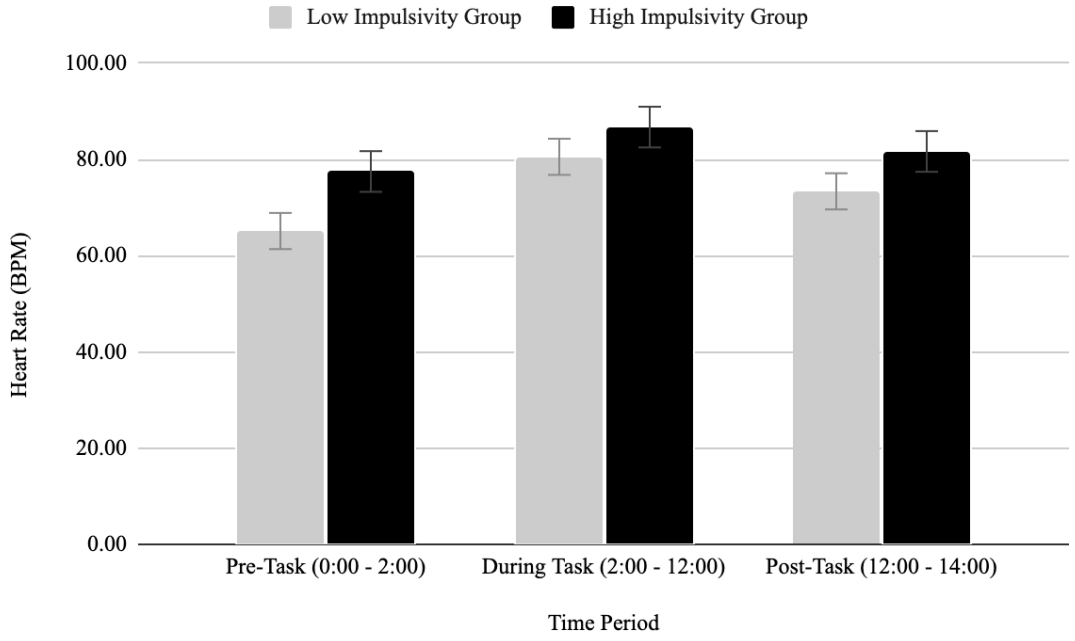
Figure 2. Trends in (A) heart rate and (B) systolic blood pressure over time for both impulsivity groups. Minute 0:00 to 2:00 was a period of deep breathing exercises, minute 3:00 to 12:00 was the duration of the mathematical computations, and minute 13:00 to 14:00 was another period of deep breathing exer- cises.



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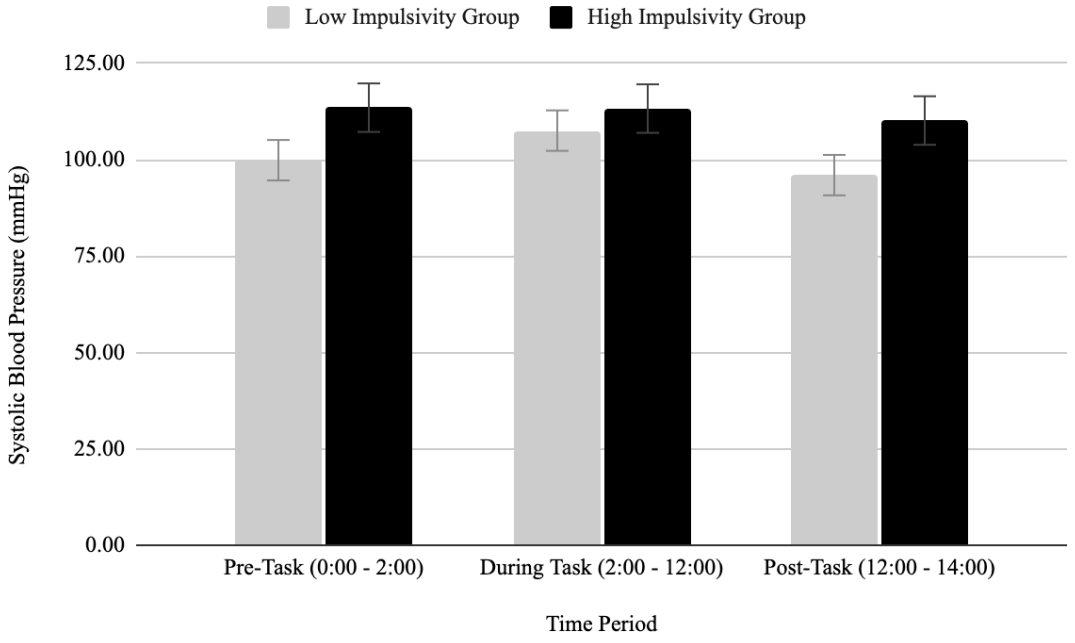

B.

Figure 3. Average (A) heart rate and (B) systolic blood pressure in each situation for both groups.

Determining statistical significance. Data was analyzed for within-group differences (com- paring pre-task, during-task, and post-task heart rate/blood pressure for both the low and high impulsivity groups) and between-group differences (comparing the low and high impulsivity groups' heart rate/pressure for the pre-task, during-task, and post-task time intervals), and P values were calculated to determine statistical significance. All significance was determined at the 95% confidence level.

A one-way ANOVA was conducted to determine if there was a statistically significant within-group difference, with three categories for the three different time periods. For heart rate, the low impulsivity group had a P value of less than 0.00001, and the high impulsivity group had a P value of 0.04207. Both these values are statistically significant; this implies that there is variation between the pre-task, during-task, and post-task heart rates in both groups. For systolic blood pressure, the low impulsivity group exhibited statistical significance (P = 0.0001) while the high impulsivity group did not (P = 0.72). From this, it is observed that there is significant variation in blood pressure for less impulsive individuals, while there may not be any variation in more impulsive individuals.

Next, an unpaired T test was used to determine if there was a significant difference between the low and high impulsivity groups (each of which was its own group in the t-test). For heart rate, the difference between the low and high impulsivity groups' heart rates throughout the study was statistically significant (P < 0.00001, P= 0.006, and P = 0.001 for the pre-task, during- task, and post-task differences). The difference in systolic blood pressure across the entire study was also statistically significant (P = 0.006, 0.008, and 0.014 for each period, respectively).

Percent change. To assess the specific variation in heart rate and blood pressure for both the low and high impulsivity group, three percent changes were calculated for each impulsivity group, one to assess the increase as the task began, another to assess the decrease as the task ended, and the final one to assess the overall change in heart rate/blood pressure.

The low impulsivity group exhibited a heart rate increase of 23.6% and a decrease of 8.9%. The high impulsivity group, on the other hand, exhibited a heart rate increase of 11.9% and a decrease of 5.8%. Reflecting the other results and the prediction, the low impulsivity group experienced a more drastic change in heart rate, but it appears that this group also took relatively longer for their heart rate to decline back to their baseline.

For systolic blood pressure, the low impulsivity group exhibited the expected pattern of a rise and then a fall (increase of 7.7%, decrease of 12%), while, unexpectedly, the high impulsivity group only decreased (with a net decrease of 2.9%). It is interesting to note how the more impulsive group's blood pressure was entirely unaffected by the stressful task; this may relate to the lower variation in heart rate exhibited by this group as well.

Results

Heart rate. As seen across the various data analysis procedures, the highly impulsive group experienced less variation in heart rate compared to the less impulsive group. This is best explained through the extreme significance (P < 0.0001) of the variation in the non-impulsive group, but the moderate significance (P = 0.04) of the variation
in the impulsive group, as well as the significantly higher (P = 0.00003) percent increase in the less impulsive group. Because the low impulsivity group exhibited a lower baseline heart rate, this increased spike resulted in the two groups' heart rates becoming approximately even (Fig. 2A, Fig. 3A). These two deductions are in line with the prediction, which stated that the low impulsivity group would have a lower resting heart rate, but
a bigger spike than that of the high impulsivity group; therefore, heart rate behaved exactly as predicted.

Blood pressure. To begin, there was a significant difference (P = between the two impulsivity groups' systolic blood pressure throughout the entire study, which was hypothesized (and relates to the pattern in heart rate). Moreover, the systolic blood pressure exhibited a pattern of increasing (8%) and then decreasing (12%) for the less impulsive group, but it only decreased (3% in total) for the more impulsive group. While this technically agrees with the prediction (in the sense that the less impulsive group displayed a greater degree of variability), it was unexpected for the impulsive group to exhibit no spike or significant variance in systolic blood pressure. This may provide further evidence

towards the hypothesis that impulsive individuals have a decreased stress response in a testing environment, as it appears to be an extreme result (considering it is a lack of a stress response). However, it still provides necessary support for the desired conclusion.

Discussion

The purpose of this research was to establish a relationship between impulsivity and cardio- vascular activity levels in an academic test-taking setting. It was hypothesized that (1) impulsive individuals would have a higher resting heart rate/ systolic blood pressure, (2) the heart rates and systolic blood pressures of both groups would be similar while they were performing the calculations, and (3) less impulsive individuals would exhibit a higher degree of variability (increase/decrease) in their heart rate and systolic blood pressure. The trends of heart rate and systolic blood pressure (Fig.2, Fig.3), as well as the quantitative statistical analysis conducted, provide support for those statements.

The high impulsivity group exhibited a significantly greater heart rate (P = 0.00001, 0.007, and 0.001) and systolic blood pressure (P = 0.006, 0.008, and 0.015) throughout the duration of the study. Fig.2 and Fig.3 show the relative heart rate/ blood pressure similarity between the two groups, and the statistical analysis points towards the conclusion that less impulsive individuals do exhibit a greater degree of heart rate variability compared to their more impulsive peers.

While this study attempted to remove confounding variables with random sampling, the small sample size may have resulted in a slight skew. Perhaps doubling or tripling the sample size to 20 or 30 would create a more generalizable result. Additionally, the monitor used to measure heart rate and blood pressure was not medical grade; this may have caused a few minor errors in the measurements. Finally, the time of day the study was conducted varied from participant to participant (either before school or after school), and while this was random for the most part, time of day does have an influence on blood pressure readings. Keeping this variable consistent may provide a more accurate reading and reduce confounding.

This study introduced the possibility that impulsivity, previously considered an aspect of personality, extends deeper within our unconscious nervous system, questioning the previous deduction that impulsive students simply aren't as academically competent. Instead, impulsivity may cause an inherent difference in the way individuals interpret, process, and react to information.

The decreased variability in heart rate and systolic blood pressure in impulsive individuals implies that impulsivity lowers one's stress response and prevents the heightened functioning that cortisol usually provides to an individual. These findings can extend beyond the field of psychology, adding further incentive to decrease the use of exams in academics and introducing the concept that personality and identity can influence the way our body reacts to certain stimuli. Overall, the results of this study open a plethora of doors towards further research involving relationship cognition, reactivity, and other aspects of the self.

References

Allen, M. T., Hogan, A. M., & Laird, L. K. (2009). The relationships of impulsivity and cardiovascular responses: The role of gender and task type. International Journal of Psychophysi- ology, 73(3), 369–376. https://doi.org/10.1016/j.ijpsycho.2009.05.014

ČAvojová, V., & Mikušková, E. B. (2015). Does Intelligence Predict Academic Achieve- ment? Two Case Studies. Procedia - Social and Behavioral Sciences, 174, 3462–3469. https://doi.org/10.1016/j.sbspro.2015.01.1019

Ismaeel, D., & al Mulhim, E. (2021). The influence of interactive and static infographics on the academic achievement of reflective and impul- sive students. Australasian Journal of Educational Technology, 147–162. https://doi.org/10.14742/ajet.6138

Li, M., Lauharatanahirun, N., Steinberg, L., King-Casas, B., Kim-Spoon, J., & Deater-Deck-

ard, K. (2019). Longitudinal link between trait motivation and risk-taking behaviors via neural risk processing. Developmental Cognitive Neu- roscience, 40, 100725. https://doi.org/10.1016/j.dcn.2019.100725

Lorenz, C., & Kray, J. (2019). Are

Mid-Adolescents Prone to Risky Decisions? The Influence of Task Setting and Individual Differences in Temperament. Frontiers in Psychology, 10. https://doi.org/10.3389/fpsyg.2019.01497

Marriott, L. K., Coppola, L. A., Mitchell, S. H., Bouwma-Gearhart, J. L., Chen, Z., Shifrer, D., Feryn, A. B., & Shannon, J. (2019). Opposing effects of impulsivity and mindset on sources of science self-efficacy and STEM interest in adoles- cents. PLOS ONE, 14(8), e0201939. https://doi. org/10.1371/journal.pone.0201939

Mathias, C. W., & Stanford, M. S. (2003). Impulsiveness and arousal: heart rate under conditions of rest and challenge in healthy males. Personality and Individual Differences, 35(2), 355–371. https://doi.org/10.1016/s0191-8869(02)00195-2

Mathias, C. W., Stanford, M. S., Liang, Y., Goros, M., Charles, N. E., Sheftall, A. H., Mul- len, J., Hill-Kapturczak, N., Acheson, A., Olvera, R. L., & Dougherty, D. M. (2018). A test of the psychometric characteristics of the BIS-Brief among three groups of youth. Psychological Assessment, 30(7), 847–856. https://doi.org/10.1037/pas0000531

Schwabe, L., Wolf, O. T., & Oitzl, M. S. (2010). Memory formation under stress: Quantity and quality. Neuroscience & Biobehavioral Re- views, 34(4), 584–591. https://doi.org/10.1016/j.neubiorev.2009.11.015

Tan, T. X., Liu, Y., Damjanovic, V., Ledford, E., Li, G., & Li, Y. (2021). Inattention, hyperactivity/impulsivity, and academic competence: Findings from three cohorts. British Journal of Educational Psychology, 92(1), 82–104. https://doi.org/10.1111/bjep.12439

Vigil-Colet, A., & Morales-Vives, F. (2005). How Impulsivity is Related to Intelli- gence and Academic Achievement. The Spanish Journal of Psychology, 8(2), 199–204. https://doi.org/10.1017/s1138741600005072