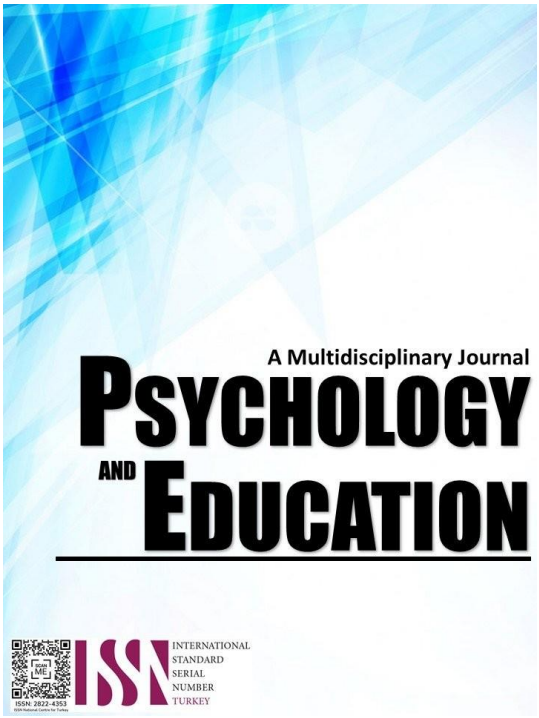
EFFECT OF STROOP INTERFERENCE ON COGNITIVE REACTION TIME AMONG COLLEGE STUDENTS IN LIPA CITY



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Research Article

Effect of Stroop Interference on Cognitive Reaction Time among College Students in Lipa City

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Abstract

A growing consensus understands the Stroop Interference as a phenomenon involving conflict and cognitive control. Research shows that incongruent stimuli create a conflict when trying to focus on both elements. It was hypothesized that people would take longer to recognize mismatched colors compared to matched colors, which can significantly impact cognitive reaction times. This study examined the Effects of Stroop Interference on Cognitive Reaction Time Among College Students in Lipa City. The researchers used a within-subject design and convenience sampling method to select participants. The sample of the study consisted of 54 college students that had equal distribution of male and female who took the same condition, such as congruent and incongruent stimuli. The researchers used paired sample t-tests to see if there's a significant difference in cognitive reaction time. Results indicated that incongruent stimuli significantly delayed cognitive reaction times compared to congruent stimuli, emphasizing the competition between automatic processes (like reading) and controlled processes (such as color identification). Participants scored faster cognitive reaction time with congruent stimuli than with incongruent ones, suggesting that they were more inclined to focus on the word itself rather than its color. The implication of the study in the real world highlights that cognitive biases can impede decision-making, especially under pressure or when faced with conflicting information and underscores the importance of educational strategies to improve reading skills and attention in children. The study emphasizes the significance of these findings and recommends that future researchers explore the Stroop effect in various countries, particularly in Southeast Asian and Asian nations, as most existing research has primarily focused on Western concepts.

Keywords: *cognitive reaction, stroop interference, college students*

Introduction

Stroop interference or Stroop effect refers to the phenomenon when the color of the word does not match the name of the word being presented (e.g. the word “green” has a color “red”) (Cherry, 2023). This effect occurs when an individual experiences confusion or distraction in perceiving the color of the word when it contradicts the word itself. Burnetti (2021) explained the concept of Stroop effect, emphasizing the contribution of John Ridley Stroop, who developed the said phenomenon. This concept demonstrated the differences between the interference of the two distinguished cognitive processes, particularly, congruent and incongruent stimuli. Moreover, the duration from when the stimulus was shown until the response was given is referred to as cognitive reaction time.

Cognitive reaction time refers to the time taken from the rapid voluntary reaction of an individual on the stimulus (Kumar et al., 2020). Meanwhile, Palfi et al. (2022) expounded the concept of cognitive reaction time in relation to the incongruent stimuli. The cognitive reaction time of an individual was reported slower than in the congruent stimuli. This means that when the person is exposed to the color word with a mismatched color, it can reduce the speed of their activity. More so, slower reaction times can negatively impact performance (D’addario & Donmez, 2019). According to Chen and Zou (2021), one of the common phenomena in psychology is the Stroop effect, implicating that the majority of the people experience this kind of difficulties in their perception skills.

The study of Sparshadeep et al. (2021) showed the significant difference between the cognitive reaction time of congruent and incongruent stimuli, reporting a higher duration when perceiving the latter one. Hence, it means that there is an interference happening when an individual is tasked with processing mismatched stimuli. This was supported by McInstosh (2020), reporting the significant difference between the two stimuli. Looking at the dissimilarity, the cognitive reaction time presented was longer in naming a color in different color words (e.g. the word “red” has a font color of blue).

Stroop interference can be understood through two theories: Selective Attention Theory and Automaticity Theory. Selective Attention Theory (Broadbent, 1958) posits that the brain can choose which information to focus on and which to ignore. In the context of the Stroop effect, responding to incongruent stimuli requires more attention than responding to congruent stimuli. As a result, the brain tends to process the easier, congruent stimuli more readily. This theory will be utilized using experimentation to evaluate the students’ ability to select and focus on the relevant information that will be shown. On the other hand, Automaticity Theory (LaBerge & Samuels, 1974) includes automatic and controlled thinking, wherein when an individual recognizes a color word that matches its actual color, the brain processes this stimulus more automatically than when the words are different colors. This automated recognition is typically quicker and easier than the controlled processing required for incongruent stimuli. Through experimentation, this theory will be utilized to determine how the students’ perceive which will be the easiest stimulus to be processed by the brain.

Despite existing cross-cultural research about the difference in Stroop tasks, more studies are necessary. In the Philippine context, there

are limited studies about the Stroop interference of college students. Few studies were also conducted in the foreign countries. If any, most of them focus solely on the medical field (Hershman et al., 2024). For this reason, continuous studies must be conducted in order to understand the impact of Stroop interference to the cognitive reaction time of the students. The majority of the research studies have few sample sizes; thus, future studies are needed to have a larger sample size (Sparshadeep et al., 2021). Stroop interference is under the scope of cognitive psychology, focusing on the ability to give attention and focus on a particular stimulus by the students. Moreover, the study of Bush et al. (2006), as cited in McIntosh (2020) explains that Stroop interference may be utilized for screening brain damage as the words themselves interfere with the ability to respond to the word quickly. With this being said, it can be argued that the Stroop interference plays a huge role in the field of psychology. In this branch, Stroop interference will be a help in investigating the principles of cognitive attention, control, and stimuli processing. This will contribute to the methods in determining such potential brain damages while undergoing the process (Farnsworth, 2025). In the educational setting, this study will be beneficial in determining the potential challenges that the students may face in relation to their attention. This study is necessary particularly to the educational setting as it presents various implications in the students' learning. According to Farnsworth (2019), Stroop interference has different implications on academe, specifically for educational strategies, such as improving cognitive flexibility and attention management in students which will help them in improving learning outcomes and academic performance.

In the Philippine context, Grumal et al. (2024) reported that the teachers perceive the attention problems that the students experienced during a lesson. Since the COVID-19 crisis, the students' attention span has become a growing problem for the teachers. (GMA Regional News Tv, 2024). In addition, there is minimal research about Stroop interference on college students in the context of the Philippines. According to McIntosh (2020), further research should also address the participant selection by randomly assigning them to provide a greater generality of results. Furthermore, the researchers believe that conducting the Stroop Task as a game will help the study to avoid the respondent's fatigue wherein participants of the study feel bored, tired, or lack of motivation to perform well during the process (Bernardino, 2019).

With these, the researchers aim to investigate how the Stroop Effect interferes with cognitive reaction time by assessing the influence of congruent and incongruent stimuli on participants' reaction times. Moreover, an experimental research design was utilized to directly observe the cognitive process of the participants by measuring their cognitive reaction time while perceiving the two different stimuli. The findings of the study aim to contribute to the field of psychology, particularly cognitive psychology as it focuses on the concept of attention and focus of the students. It will also be beneficial to the academe as it will help the teachers detect certain potential challenges that the students face in relation to their cognitive attention and focus on certain stimuli. The researchers chose the college students in a higher education institution (HEI) in Lipa City as their sample because they are the most compatible with the research objectives. Ultimately, this study seeks to determine the outcome whether the Stroop effect, particularly to the congruent and incongruent stimuli, interfere with the perception of the respondents. Lastly, the study will be helpful to the students and the institution as it will help in overcoming cognitive problems, especially attention problems.

Research Questions

The study aims to determine the cause-and-effect relationship between congruent and incongruent stimuli and cognitive reaction time. Specifically, it seeks to answer the following:

1. What is the level of cognitive reaction time of the participants assigned with:
    1.1. Congruent stimuli
    1.2. Incongruent stimuli
2. Is there a significant difference in cognitive reaction time between participants assigned in congruent and incongruent stimuli?
3. What is the effect of Stroop interference on cognitive reaction time among college students?

Literature Review

Congruent Stimuli

In the study conducted by Šömen et al. (2023), congruent stimuli are defined as instances where the letter string articulates the name of the color that corresponds to the hue in which the string is presented (e.g., the word "RED" displayed in red ink). Ménétré and Laganaro (2019) suggest that the most efficient cognitive strategy for processing a congruent trial (e.g., the word "BLUE" depicted in blue font) is to prioritize the semantic interpretation of the word over its color representation. Hershman et al. (2020) state that interference in the Stroop task comes from two sources: information conflict between word meaning and color, and task conflict from reading the word and responding to the color. According to the findings, the congruent trials are the shortest in response times and longest for incongruent, also with little difference between the neutral stimuli. Hershman et al. (2022) recognize two types of conflict in the Stroop color- word task: (1) an initial conflict in distinguishing relevant color from the automatic reading of the irrelevant word, and (2) a later information conflict arising from matched and mismatched color. Parris et al. (2023) highlights the role of task sets in cognitive processes, particularly within selective attention where individuals must navigate between or manage competing tasks. Rothermund (2022) stated that the word "BLUE" in blue ink facilitates faster responses in congruent trials but it results interference in incongruent trials, leading to a stronger Stroop effect when the majority of pairing are congruent.

Furthermore, it was found in the study conducted by Panda (2024) that participants exhibited faster reading speeds for congruent list words compared to incongruent ones. This occurrence emerged from the conflict that occurs when the meaning of a word is different with the color in which it is presented. In addition, Prével et al. (2019) further explained that a less cognitive attention is directed toward incongruent- congruent sequences while congruent stimulus is typically processed more faster following exposure to another congruent stimulus. Caron et al. (2020) confirm these findings, stating that participants tend to give greater focus to congruent trials over incongruent ones. It emphasizes a major conflict between identifying and verbalizing its meaning. As stated by Baghdadi et al. (2021), to select the appropriate answer, individuals must suppress their habitual responses and exercise their inhibitory control.

Incongruent Stimuli

In the study of Pan et al. (2022), it was shown that in the incongruent trials, the memory sample was also a color word, but its meaning is different from the color of the word. According to Toth (2019), the response accuracy on incongruent trials being significantly poorer and longer to respond compared to those on control and congruent trials. Prével et al. (2021) also stated that participants are usually respond more slowly when the ink-color and word meaning are different (incongruent) than when they are similar (congruent), an effect known as the "congruency effect" caused by the habitual word-reading process. Moreover, In the study of Panda (2024), the study revealed that the participants tend to read congruent list words faster than those of the incongruent one. When the meaning of the word is incongruent with the color of the ink, a conflict occurs.

As stated by Suzuki et al. (2021), in interference tasks sequential congruency effects are observed in which reaction times are longer for incongruent stimuli preceded by congruent than incongruent stimuli while shorter for congruent stimuli preceded by congruent than incongruent stimuli. Participants were slower to respond to incongruent rather than congruent words (Pickering et al., 2022). It was observed in the study of Rothermund (2022), that there is a reduction in the strength of Stroop interference for specific words that were mostly presented in an incongruent color compared to words that were mostly presented in a congruent color. As stated by Algom (2019), incongruent stimuli can result in a large Stroop effect rather than congruent stimuli. With incongruent stimuli, participants generally take more time to respond and make more errors because of the interference that occurs between the meaning of the letter string and the actual color in which the string is written (Šömen et al., 2023). Therefore, in the study of Panda (2024), it was revealed that the participants tend to read congruent list words faster than those of the incongruent one, experiencing conflict when the ink color doesn't align with the meaning.

Cognitive Reaction Time

The cognitive reaction time, particularly of the students, is defined as the duration recorded from when the stimulus is given until an oral response takes place. Thus, to assess the cognitive system's capacity, limitation, and abilities, measuring this condition is considered to be an efficient strategy (Reigal et al., 2019). Moreover, measuring the human's cognitive reaction time might be a complex process, but various scholars invest time to investigate this phenomenon (Fang & Davis, 2017, as cited in Cahello et al., 2023). Above all, cognitive reaction time is a calculated conscious response to an external stimulus from its distribution until it is perceived by the sensory organs per se that sends chemical signals to the brain for the response. The study by Mashburn et al. (2019), explained that cognitive reaction time is believed to be a good indicator of the speed and efficiency of mental processes and is a ubiquitous variable in the behavioral sciences. Despite this popularity, there are numerous issues associated with using reaction time (RT), specifically in differential and developmental research. However, the cognitive reaction time may vary depending on the type of stimulus that will be perceived.

As mentioned by Collins et al. (2022), the slowest response times (RTs) occur during incongruent trials where the color displayed does not match the word's meaning (e.g., the word "RED" shown in blue). Since both congruent trials and same-response incongruent trials involve response facilitation, the observed difference between the two likely represents semantic facilitation rather than semantic conflict. Based on Ruhl's (2023) study, the delay in cognitive reaction time indicates that identifying a word's color when it spells a different color (the incongruent stimuli) is significantly more difficult than determining the same word's color when it spells the same color (the congruent stimuli). In addition, Gutuman et al. (2022) found that participants are more experienced in reading words than in labeling colors, which highlights the difference between the two conditions and explains the greater difference in measuring the cognitive reaction time of the participants.

As stated by Hasshim et al. (2019), cognitive reaction time distributions exhibit the Stroop effect. The current study seeks to fill the void by adjusting both semantic and response intervention in a manual response Stroop task as well as investigating the way these various elements of Stroop interference influence the response time distribution. In the words of Hershman et al. (2023), the cognitive reaction time currently demonstrates conflict in incongruent stimuli, and it consists of quicker cognitive reaction time to congruent stimuli. In Incongruent stimuli, the cognitive reaction time is slower due to the conflict it creates. Cognitive reaction time is faster for congruent stimuli due to the less conflict. Conflicts challenge the cognitive reaction time of people. When obstacles are met people find it hard to adjust during such situations then it costs a lot of time.

Congruent Stimuli, Incongruent Stimuli and Cognitive Reaction Time

Panda (2024) conducted a study examining the variances in cognitive reaction time when processing congruent versus incongruent words. The findings indicated that participants exhibited a significantly faster reading speed for congruent words compared to their

incongruent counterparts, thereby corroborating the initial hypothesis. Notably, participants demonstrated superior efficiency in reading tasks relative to recalling and recognizing color names. The evidence suggests that the interaction between participant demographics and the characteristics of the stimuli has a statistically significant impact on reading rates. In a parallel investigation, Gautam (2023) explored differences in cognitive reaction time utilizing the Stroop Color-Word Test among young, healthy medical students. The study identified significant differences in cognitive reaction time that were associated with congruent and incongruent stimuli. The findings indicate that the participants exhibited longer cognitive reaction times regarding incongruent stimuli and also revealed that there were no significant differences in male and female cognitive reaction times. Sjoberg et al. (2023) similarly found no notable differences in the gender differences in the Stroop effect suggesting that the initial hypothesis was not supported.

A study found significant variations in terms of cognitive reaction time in both conditions, leading to the rejection of the null hypothesis. McIntosh (2020) emphasized the influence of word semantics on color recognition, showing that the participants took longer to identify mismatched words rather than congruent ones. Gutuman et al. (2022) confirmed the results, indicating that the participants responded more rapidly when the color matched the word's meaning. These findings assert that the participants are more likely to perceive color as corresponding with the word's meaning. This distinction highlights the challenges in both conditions, and stresses the crucial point of color-word congruence in enhancing response efficiency. Furthermore, a study comparing undergraduate and graduate students found significant differences in processing both conditions, suggesting that task-induced Stroop interference, as the cognitive reaction time was particularly longer than for congruent stimuli (Rezaei, 2019).

Conversely, a study showed no notable differences in Stroop or reverse-Stroop interference. Takahashi and Grove (2020) found that the calculations for both types of interference yield smaller Intraclass Correlation Coefficients (ICCs) compared to the obtained test for both Stroop tasks. Additionally, Parris et al. (2019) reported no significant differences in both variables, as they investigated whether response mode varies the phonological facilitation produced by the irrelevant word. These results are contradicted by Coltheart et al.'s reported final position overlap effect and indicate that there are no qualitative differences in phonological processing between manual and vocal responses. As mentioned by Hasshim et al. (2019), the study revealed no significant differences in Stroop interference and cognitive reaction time, suggesting that semantic conflict nor response conflict serves as a reliable indicator of these parameters within the task framework. The working memory and processing speed of youth participants did not significantly predict performance on the Stroop test, unlike those of adults, indicating no notable differences between the variables (Flowers et al., 2023).

Methodology

Research Design

This study utilized a single-factorial experimental design, which effectively compared the main effects of independent variables on dependent variables (Adamson & Prion, 2020). According to None & Sankar (2022), in single-factorial design, the researchers employed a within-subject design, evaluating the same participants under two conditions: congruent and incongruent stimuli. When a word's meaning matches its font color (e.g., "green" written in green) it is transpired as congruent stimuli. While incongruent stimuli highlighted a mismatch (e.g., "green" written in black) (Charlotte Ruhl, 20203). Thus, the study was able to explore the effect of Stroop interference on the participants' cognitive reaction time through a single-factorial experiment. Convenience sampling and random assignment were employed to address extraneous variables to assure that participant bias and sampling error were minimized or eliminated.

Respondents

The present study utilized a convenience sampling method that relies on the accessibility, availability and willingness of the participants to volunteer (Golzar et al., 2022). It enables the researcher to efficiently collect data and significantly reduce the time required since the target population is accessible. Additionally, the study used random assignment that is crucial to ensure for generating similar groups, as highlighted by Siedlecki (2020).

Through random assignment, participants are exposed to both conditions that allow the investigation to know the differences in cognitive reaction time. Individuals with vision impairments, including poor eyesight, color blindness, monochromacy, nearsightedness and farsightedness are excluded from experiment. Participants who wear prescription glasses and with corrected-to-normal vision were also excluded.

The study consisted of 54 respondents who voluntarily participated in the experiment. The researchers obtained ten individuals from the following departments: the Colleges of Nursing (CON), the College of Business and Accountancy (CBA), the College of International Tourism and Hospitality Management (CITHM), and the College of Computing Technology and Engineering (CCTE). Additionally, four participants were selected from the College of Education. In line with this, the total number of participants is sufficient enough to conduct the experiment, providing statistical power to test the effects on both conditions (Hersmann et al., 2024)

Five psychology students from the College of Liberal Arts were selected to conduct a pilot experiment. Pilot experiments were conducted to prevent the participants from any potential familiarity with the experimental procedure and to ensure the functionality of the materials before the main experiment.

Instrument

The researchers utilized a demographic data form to gather participant's age, civil status, sex, department, course/program and eyesight condition. The data gathered was used to assess the participant's eyesight condition, including poor eyesight, color blindness, monochromacy, nearsightedness, farsightedness as well their reading capabilities. Participants with visual impairments, including corrected- to-normal vision and those who wore prescription glasses were excluded from the study. These instruments were used and validated in some studies. According to Casagrande et al. (2024), a demographic data form was used to classify the participant's age, gender, and education level. On the other hand, Cole et al. (2023) used a demographic profile to identify participants who have a visual impairment.

To measure cognitive reaction time, the stopwatch was used as McIntosh (2020) highlights the utility of the stopwatch in the cognitive responses of the participants in both conditions. The stopwatch was designed to operate regardless of the pauses or hesitation that the participants experienced during the experiment. The total duration of each test was recorded carefully after the completion of the test by the participants.

The powerpoint presentation was the key component of the study. The powerpoint presentation contained a chart, featuring the congruent and incongruent words that the participants read aloud. Schneider (2020) utilized a laptop to present visual materials for the participants to assess when the text appeared on the laptop screen that was shown against a white background. Similarly, Cole et al. (2023) presented the stimuli on a computer monitor to regulate the word presentation and measure the participant's reaction times. On the other hand, Kalantari et al. (2021) employed a projector and a screen to administer the Stroop test in a classroom setting. A study conducted the Stroop test in a dimly lit room, ensuring the participant's isolation to enhance focus and maintain controlled conditions (Hershmann et al., 2023).

Procedure

The researchers prepared various documents, including approval letters, letters of invitation, letters to the dean, letters to subject matter experts (SMEs), and informed consents. After these documents were prepared, it was submitted to the comprehensive research methods for validation and approval by the subject matter experts. Once the subject matter experts approved the research methods, validation forms and letters of approval were submitted to the research office and creative works for final approval. After the final approval, documents were forwarded to the deans to formally ask for permission to conduct experiments involving their students.

The researchers selected five psychology students for a pilot experiment and invited ten participants from each department to participate in the actual experiment using a letter of invitation. Participants were assessed individually in one session using two patterns: Type AB (congruent stimuli first, then incongruent) and Type BA (incongruent first, then congruent). The order was randomly assigned using a fishbowl technique. A laboratory schedule was arranged at the participants' convenience, and the Testing Room of the laboratory was organized with curtains on the windows and glass door to minimize distractions. The researchers controlled the mood of the room by using warm lighting. The brightness of the project was set to only 50 percent in order to prevent the participants from experiencing eye straining. The necessary materials, including a laptop, projector, and stopwatch, were set up to ensure comfort. A pilot experiment was conducted beforehand to ensure that all materials functioned correctly and to prevent errors during the actual experiment.

During the briefing, participants were provided with informed consent, which included information about the use of deception, and the researchers discussed the research objectives through a cover story. Participants' concerns about the session were addressed. To achieve the study's goal, certain details about the experiment were omitted.

The experiment was labeled "PsychCOLORgv!" and used to measure how color influences human perception, particularly memory for various stimuli in the environment. To guarantee participants fully understood the procedures, the researchers provided a detailed explanation and followed a specific pattern (e.g., Type AB first, followed by Type BA). To avoid confusion, instructions regarding the deception were aligned with the actual study protocols. During the presentation, participants were shown 20 words in a sequence, and the colors used in both conditions are blue, green, red, and purple. The participants were instructed to read them from left to right and then downwards. This method aimed to explain the participants' task and minimize any doubt on the instructions.

During the experiment, researchers use a stopwatch to measure participants' cognitive reaction time. Two experienced individuals operated the stopwatch and timer. The stopwatch was started when the stimuli were presented and stopped after participants finished reading the 20 words. The researchers recorded the time for each session and held a debriefing afterward while presenting another informed consent containing the objectives of the study to explain the true purpose of the study. Participants were given the option to confirm their willingness to continue participating in the experiment. If participants opted to withdraw, their data were omitted from the study. At the end of the session, participants received a token of appreciation for their involvement.

Data Analysis

In order to analyze the collected data, the researchers used proper statistical approaches to compare the variations in cognitive reaction time between the two conditions (i.e., stimuli) by using Jamovi Software. Murat et al. (2019) states that Jamovi is a free and convenient statistical software designed for social scientists, that emphasizes its user-friendliness and features appropriate for educational measurement research at both undergraduate and graduate levels. It also further simplifies through data analysis in a short time.

The statistical methodologies used by the researchers are the weighted mean, a variant of mean that can be computed by multiplying the weight or probability related by a standard event or equivalent to a quantitative value followed by adding all of the values. In addition, the standard deviation is most commonly used to measure such variations that gives a factual assessment when it comes to variability. It was a crucial component in many statistical calculations, as it effectively summarizes the departures from the mean effectively.

Paired t-test was used by the researchers to differentiate the two conditions which are the congruent and incongruent stimuli to see if there's a significant difference in cognitive reaction time. The paired t-test compares the means of two variables of a single group in computing the dissimilarity of both values. When comparing two closely related groups, the paired t-test was utilized (Glechmann, 2020). It is applicable when the two groups being compared are interrelated or dependent on each other. Additionally, analyzing the means of the two conditions assists researchers in drawing conclusions about the population. These were very useful and helpful when these tests were able to be interconnected or dependent on one another. To handle the statistical treatment of the experiment, the researchers seek the help of a data analyst to better examine the data. Additionally, the assumption of paired t-test was analyzed to assess the validity and reliability of the statistical methodology employed such as:

Normality: The normality test is an important process of the statistical procedure as it deals in choosing an appropriate measurement of central tendency and statistical techniques in facing continuous data in data analysis (Anaesth, 2019). Whether the sample data arise from a large sample or population that is normally distributed, it is still necessary to determine if it confirms the results of the normality test since normality tests verify that the data has a normal distribution that is significant for the investigation.

Homogeneity of Variance: Homogeneity tests were used to determine if there were equal variances between the cognitive reaction times of the two conditional groups (i.e., congruent and incongruent stimuli). The homogeneity of variance involves comparing the variability in different groups and demonstrating similarities or a lack of significant deviation from the expected distribution (Odoi et al., 2022).

Ethical Considerations

During the screening, researchers ensured that participants had no eyesight issues affecting the experiment. Before the actual experiment, the researchers used deception, and the researchers discussed the research objectives through a cover story. Two informed consent was given to the participants, outlining the experiment's purpose, risks, and participant rights, noting minimal risks involved. The researchers prepared all the materials that were validated by the research adviser, followed by the panel of evaluators to reduce the unforeseeable risks and harm to the participants. Researchers took steps to minimize distractions that could impact performance. Researchers carefully examined the projector's placement, font size, brightness, and distance. Participants also received monetary compensation after the experiment.

Furthermore, the researchers protected participants' rights by preventing any adverse consequences for them. Participant information was kept confidential, with each assigned a unique code for anonymity. All data was securely managed and properly disposed of after the activity. In this research, the first condition incorporated a deception that this was not an experiment but just a game. The researchers began by explaining the background and the procedure of the game. After that, the instructions were given to the participants. After the game, the researchers conducted a debriefing to disclose the true purpose of the game. During the debriefing, the researchers outlined the actual purpose of the study, the rights of the participants and discussed the unforeseeable risks of the study. Once the true nature of the experiment was revealed, the participants were given the option to continue or withdraw without any consequences. The study ensured that the deception posed no harm, and all personal information was securely stored and kept confidential. Only researchers had access to the data, which was protected with code names. After the study, all collected data was shredded to ensure proper disposal.

A Philippine law known as Republic Act 10173, or the Data Privacy Act of 2012, attempts to protect the fundamental human right of privacy, particularly about personal data. The researchers adhered to the Republic Act by deleting and ensuring the safety of the information of each participant after the experiment. The researchers maintained the confidentiality of the information they acquired from participants. The researchers ensured that there was no repercussion in withdrawing and that the participant's participation was completely voluntary.

Results and Discussion

Table 1. *Level of Cognitive Reaction time*

	N	*Mean*	*SD*	*Verbal Interpretation*
First condition (Stopwatch)	54	14.1	5.09	Fast cognitive reaction time
Second Condition (Stopwatch)	54	25.5	7.05	Average cognitive reaction time

Verbal Interpretation: Below 10 seconds (Very Fast), 10–20 seconds (Fast), 20–30 seconds (Average), 30–40 seconds (Slow), Above 40 seconds (Very Slow)

Table 1 represents the first condition and second condition of cognitive reaction time of college students using stopwatch. The data show that the stopwatch in the first condition has a lower result with a Mean score of 14.1 (SD = 5.09) which signifies "fast" cognitive reaction time. Meanwhile, the second condition has a mean score of 25.5 (SD = 7.05) corresponding to a verbal interpretation of

"average" cognitive reaction time. Results indicate that cognitive reaction times are faster in congruent trials compared to all incongruent trials (Hershman, Levin, & Henik, 2021). Spinelli and Lupker (2020) state that incongruent stimuli in the Stroop task cause substantial interference, resulting in slower response times, higher error rates, and increased cognitive load compared to congruent stimuli. The brain mitigates this interference through conflict monitoring, contingency learning, and adaptation to the frequency and context of incongruent trials. Congruence between the ink color and the word meaning significantly impacts color- naming performance. Specifically, responses are slower and less accurate in the incongruent condition than in the congruent condition (Pan, Zhang, Hu, et al., 2022). Additionally, colored patches do not possess any structure that can be associated with readable words; they lack orthographic features.

Moreover, the study by Dallaway et al. (2023) found that participants exhibited faster accuracy and response speeds when exposed to congruent word stimuli in comparison to incongruent word stimuli. Notably, cognitive reaction times improved as the duration of the task increased. In the context of the number of Stroop tasks, accuracy was higher following incongruent word Stroop stimuli than congruent ones. This highlights a significant difference in cognitive reaction times related to congruent and incongruent stimuli among college students. The working memory Stroop task involves naming the color of a word while simultaneously reading the color word in working memory. Previous studies utilizing this Stroop task have demonstrated that the congruence between the color patch and the color word significantly influences color naming and working memory. Task performance declines when the color patch is semantically incongruent with the color word. Overall, comparison of congruent and incongruent scores shows that they have marked differences.

Table 2. *Paired Samples T-test*

	statistic	*Mean difference*	*p*	*VI*		*Effect Size*	*VI*
First Condition (Stopwatch)	-12.4	-11.4	< .001	HSD	Cohen's d	-1.69	Large Effect
Second Condition (Stopwatch)							
Student's							

Note: H_a: μ Measure 1 - Measure 2 ≠ 0; p < 0.05 (Significant), p < 0.01 (Very Significant), p < 0.001 (Highly Significant)

Table 2 presents the significant difference between congruent and incongruent stimuli. Paired sample t test was used to check the difference and the results indicated that the assumption of normality was not violated (W = 0.975 , p = 0.316) verifying that the distribution of the scores was normal. The mean difference of -11.4 is deemed significantly, showing that the second condition (incongruent stimuli) scored an average of -11.4 higher than the first condition (congruent stimuli).

The results were supported by the study conducted by Tong et al. (2020), which denotes that there is a significant difference between congruent and incongruent conditions, explaining that congruent stimuli lead to greater integration compared to incongruent stimuli. Since both conditions were normally distributed, it is concluded that the measured cognitive reaction measured in the participants for both conditions are consistent. The significant difference between the two conditions were also explained by the study of McIntosh (2020) which reported a significant difference between the reported time for color- naming between congruent and incongruent stimuli. This implies that naming colors in incongruent stimuli takes longer cognitive reaction time than naming incongruent stimuli caused by the Stroop interference. Parris (2021) noted that Stroop interference is the golden standard measure of selective attention and cognitive reaction time, describing it as a phenomenon that delays cognition processing between the congruent and incongruent stimuli. Consistently, the study of Hershman et al. (2021) also highlighted a significant difference between the two conditions. In interference tasks, responses to congruent stimuli are faster when preceded by another congruent stimulus, while responses to incongruent stimuli are slower when preceded by a congruent stimulus (Suzuki, 2021).

Table 3. *Effect of Stroop Interference on Cognitive Reaction Time*

	statistic	*Mean difference*	*p*	*VI*		*Effect Size*	*VI*
First Condition (Stopwatch)	-12.8	-11.4	< .001	HSD	Cohen's d	-1.69	Large Effect
Second Condition (Stopwatch)							
Student's							

Note: H_a: μ Measure 1 - Measure 2 ≠ 0; Cohen's d Interpretation: Effect size >0.2 = Small effect, >0.5 = Medium effect, > 0.8 = Larger effect

Table 3 presents the significant difference between congruent and incongruent stimuli. The results reveal that congruent stimuli demonstrate a faster cognitive reaction time (M = 14.1, SD = 5.09). The data also shows that Stroop effect has a large effect towards cognitive reaction time in college students since it has an effect size of -1.69. As a result, Stroop effect can benefit the students through the educators in which they can come up with teaching techniques that can potentially improve their learning outcomes and their academic performance and to enhance the cognitive functions and attention management of the students. Furthermore, Stroop effect can be applied in real-word settings for instance, the Stroop task can be used to assess individuals with cognitive impairments that exhibit increased Stroop interference, indicating difficulties with cognitive control and selective attention.

The data indicate that utilizing Cohen's D revealed a large effect size (-1.69), suggesting that the research findings significantly impact participants both within the institution and beyond. In the study conducted by Amborosini et al., (2024), it was noted that the corresponding effect sizes were generally larger, particularly regarding cognitive reaction times when participants were exposed to congruent stimuli. This was likely because during incongruent trials, they faced interference or conflict with the task due to a lack of alignment between stimulus and response dimensions. As a result, the color-word Stroop task demonstrated that greater Stroop effects

occur with congruent stimuli compared to incongruent ones.

The Stroop effect can also be applied to various fields, exploring its implications beyond its impact on cognitive reaction times including neuroscience, clinical psychology and educational settings. One of some studies that explored its implications was the study of Farnsworth (2024) where it was stated that the Stroop effect has both significant applications and implications across various fields particularly on educational strategies. The study showed that understanding Stroop effect can be used to create interventions that are intended to improve reading skills and attention of children . On the other hand, the study of Cherry (2023), showed that conflicting information can hinder people's ability to plan, manage distractions, and make decisions under pressure. This statement is supported by the study of Scaltritti & Sulpizio (2022) in which the findings revealed that a person's attention control can be affected while processing congruent and incongruent stimuli in Stroop tasks and it was observed by Chen & Zou (2021) that interference from other factors can negatively impact people's concentration and hinder their ability to react when responding to a specific stimulus.

Conclusions

The cognitive reaction time of the participants reveals a notable difference when exposed to congruent and incongruent stimuli. Participants exhibited faster reaction times on congruent stimuli due to the lack of conflict between the meaning and appearance of the stimuli which permitted more efficient processing. In contrast, the cognitive reaction times of the participants are slower when the incongruent stimuli were presented. These discrepancies increased cognitive loads, which developed delays in response. The delay of the cognitive reaction time is ascribed to the cognitive interference from the Stroop effect which requires additional effort to resolve the conflict between the two stimuli. The difference between these two conditions implies that external factors or the stimulus can influence cognitive reaction speed. It supports the notion of the theory that incongruent stimuli increase cognitive load, leading to longer response times. This effect was evident among college students, as their brains exerted extra effort to process conflicting information that caused noticeable delays. Ultimately, the research underscores the significant impact of Stroop interference on cognitive reaction time, emphasizing the mental effort required to process incongruent data.

The study's sample consisted only of college students from a higher education institution (HEI) in Lipa City, limiting the ability to generalize the findings to a larger population. All participants were screened to ensure that the participants had normal vision, as visual stimuli were crucial to the experiment. Participants with undiagnosed or diagnosed visual impairments were excluded from the study. While the experiment was operated in a controlled condition, there may be limitations in the real world when applying the findings to the real-world, where external factors could influence the students. Hence, Stroop interference is multifaceted and requires careful consideration. Implementing such games as a deception presents challenges as it relates to the difficulty of preventing the participant's frustration or level of fatigue while doing Stroop Effect. On the side of carefully considering the ethical implications and implementing appropriate protection, it is possible to create a captivating and educational game that respects the rights and well-being of participants. The experimental pattern and the small number of stimuli constraint a greater understanding of how colors influence memory and perception. Furthermore, the omission of some details due to the cover story may hinder the participant's comprehension of the experiment, potentially influencing their performance.

Future studies should expand their research scope to build upon the findings of this study and explore the other factors that may cause longer cognitive reaction time to the participants. The use of stopwatch in the experiment may introduce human error so future researchers should use more precise methods such as computerized reaction time measurement to improve the accuracy of data. In line with the results, it is recommended that the future researchers should explore the concept of Stroop effect in different contexts such as in educational, industrial, and other fields that require cognitive skills. Moreover, the researchers recommend that researchers must conduct research about Stroop effect in various countries, particularly in Southeast Asian and Asian nations, as most existing research on the Stroop effect is based on Western concepts. Gender differences must be explored by researchers in order to gain a deeper understanding of how sex-related factors can influence Stroop interference and cognitive reaction time.

Additionally, future educators can provide cognitive training activities like Stroop-like tasks or time reading assessments to improve student's cognitive flexibility and manage cognitive interference to sustain focus. Policymakers should take these findings into consideration when implementing or designing curricula and educational policies. By doing so, they can create a school's environment and teaching practices that support improved reading abilities and cognitive processing skills.

The findings of this study contribute to our understanding of cognitive processing in college students and provide insights into how external stimuli can influence cognitive reaction times in real-world situations, suggesting potential applications for enhancing cognitive performance across various domains.

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