Graduate Student Journal of Psychology
Spring 2025 - Vol. 24

Effects of Anxiety on Attention-Based Tasks in a College Population

Jacob DeSoto[1,2] & Jessica Gaby[2]
[1]*Department of Psychology, Western Carolina University*
[2]*Department of Psychology, Middle Tennessee State University*

Previous literature suggests that trait anxiety may lead to diminished global processing, and therefore, a local processing bias (Basso et al., 1996), which may contribute to a narrowed scope of attention and impaired cognitive flexibility. Additionally, there is conflicting data on how anxiety interacts with performance on the Stroop task (e.g., Ursache & Cybele Raver, 2014). To understand this relationship, the authors used the State-Trait Anxiety Inventory (STAI) to divide participants into groups based on their levels of anxiety. Specifically, the researchers explored the effects of state and trait anxiety on college students' attention using the Navon task and the Stroop task. The Navon task was used to compare the performance of people with high and low trait anxiety, utilizing two t-tests to analyze local and global processing. Four groups were created for the Stroop task: high trait/low state, low state/high trait, high trait/high state, and low state/low trait, which were compared through an ANOVA. No statistically significant differences were found in performance on the Stroop and Navon tasks based on state or trait anxiety. This may be due to the age range of participants and the lack of clinical elevation of these factors. The findings suggest that moderate levels of anxiety may not impact attention drastically in a college population.
Keywords: anxiety, attention, college, Stroop task, Navon task

The current study examines the potential relationship between anxiety as measured by the State-Trait Anxiety Inventory (STAI) and performance on the Navon and Stroop tasks, reflecting different aspects of attention that are crucial for academic success. These cognitive tasks measure different aspects of attention, including visual global and local processing, and executive inhibition (Miyake et al., 2000; Navon, 1977; Stroop, 1935). We measured two types of anxiety: trait anxiety and state anxiety. Trait anxiety can be defined as the general level of anxiety a person feels on an everyday basis, whereas state anxiety is the level of anxiety they feel in the current moment (Shilton et al., 2019; Spielberger et al., 1983). We aimed to examine how anxiety may impact a person's attention, executive functioning, and visual processing. If there is indeed a difference in performance based on anxiety, this could affect future treatment considerations for college students with anxiety diagnoses.

We hypothesized that individuals with high levels of trait anxiety would have a local processing bias in the Navon task, specifically demonstrated by slower reaction times on global processing than participants with low trait anxiety for the Navon task. Additionally, we hypothesized that participants with high trait anxiety would have faster reaction times on local processing than participants with low trait anxiety. For the Stroop task, we hypothesized that individuals high in state anxiety, those high in trait anxiety, and those who score high in both types of anxiety would have slower reaction times on the incongruent trials of the Stroop task than those low in both types of anxiety. This study further explores the relationship that may exist between anxiety and interference in each of these tasks, leading to a better understanding of how state and trait anxiety impact performance on attention-based tasks in a college population.

Anxiety in College Students

College can be an emotional experience for students, with the potential for many first-time, unfamiliar experiences. While many of these experiences may be enjoyable and eye-opening, some aspects of college, such as academic expectations or financial concerns, may lead individuals to experience high stress and anxiety levels. In one study, 40% of undergraduate university students displayed anxiety symptoms (Beiter et al., 2015). Asher BlackDeer et al. (2021) collected a sample of 117,430 students from over 100 college institutions and found that 9.2% of the overall sample displayed symptoms of anxiety. These studies demonstrate how prevalent anxiety can be in college students across the United States and suggest that pressures regarding academic performance may be a contributing factor (e.g., Asher BlackDeer et al., 2021; Beiter et al., 2015).

Research frequently suggests an impact of state-level anxiety on performance in specific contexts, such as test anxiety or statistics anxiety (e.g., Cassady & Johnson, 2002; Chew & Dillon, 2014; Hoegler & Nelson, 2018). More broadly, literature on trait anxiety suggests an inconsistent impact on academic performance. For example, Vitasari et al. (2010) found that in university engineering students, there was a small but significant correlation between high anxiety as measured by the STAI and low academic performance. Another study found a significant indirect correlation between low academic performance and trait anxiety in middle school students (Owens et al., 2012). However, Chaplin (1989) suggests that it may not be the anxiety itself but rather how an individual reacts to anxiety that determines the impact on academic achievement.

Anxiety and Attention

Attention may have an important impact on academic achievement. In addition to academic achievement, anxiety appears to impact attention (Najmi et al., 2012; Pacheco-Unguetti et al., 2010). The executive control network, or executive attention, consists of problem-solving, working memory, and managing conflicts. Executive attention is a part of the broader category of executive functioning and can be investigated using the Stroop task, which requires executive control when managing conflicting information.

The scope of attention involves the ability to expand or narrow one's visual focus relative to the size of an individual's visual environment (Kosslyn et al., 1999; Najmi et al., 2012). One study suggests that undergraduate students with high levels of trait anxiety had an impairment in expanding the scope of their attention compared to students with low levels of anxiety. The authors of this study suggest the scope of visual attention may be related to global and local processing (Najmi et al., 2012).

Global and Local Processing

When someone looks at a painting, do they start by recognizing the entire picture or by focusing on the detail within the painting? This question concerns the global and local elements found within the painting. Regarding visual perception, local processing focuses on the individual elements that make up a scene (Nayar et al., 2015). Global processing involves seeing all the individual elements that create the scene and using this information to create a comprehensive global image (Navon, 1977; Nayar et al., 2015). The theory of global precedence states that visual perception tends to start from seeing the big picture (the forest) first and then noticing the finer details (the trees) (Navon, 1977).

Research indicates that young children may rely mainly on local-level strategies and develop global-level strategies similar to the average adult between the ages of 7 and 10 (Nayar et al., 2015). This demonstrates that humans may naturally adapt global processing strategies as their brains develop. This may be because a child's prefrontal cortex is still developing (Tsujimoto, 2008). As humans develop, there are instances where these global-level strategies may be beneficial. For example, Woltin et al. (2012) found that participants from a college sample correctly understood the communicative intent of a written message (sincere or sarcastic) more frequently when they were globally primed than when they were locally primed.

Anxiety and Global/Local Processing

High trait anxiety may impact an individual's scope of attention on global/local tasks, leading to a local-level processing bias (Basso et al., 1996; Becker et al., 2017; Najmi et al., 2012; Shilton et al., 2019). Shilton et al. (2019) found that participants with high trait anxiety were biased toward processing local-level visual stimuli in a global-local visual processing task, with less of a preference towards global-level processing. In contrast, their high state anxiety group displayed greater interference (slower reaction times) from global stimuli when attempting to process the local-level stimuli compared to their low state anxiety group. This would indicate that, unlike trait anxiety, no local processing preference appears to result from state anxiety (Shilton et al., 2019).

On the other hand, Basso et al. (1996) found that male participants exhibiting symptoms of depression or anxiety displayed a bias towards local processing, suggesting that these pathologies diminish global processing. Becker et al. (2017) used a Navon task to demonstrate that trait-level anxiety may lead to a local processing bias. According to Tyler and Tucker (1982), individuals with trait anxiety may rely more on their left hemisphere in visual perception, such as performing the Navon task. If this is true, this may explain some of the local processing bias. This detail-focused (local-level) perceptual bias may indirectly lead to maladaptive behaviors, such as an eating disorder (Becker et al., 2017).

Stroop Task and Executive Attention

If a student were to shout out an answer without raising their hand during a lecture, that would be an example of failing to inhibit a response. The ability to restrain one's unwanted responses is known as response inhibition (Albert et al., 2013). In this study, one task we used to measure attention was the Stroop task. In this task, participants are shown multiple trials of the color names in various colors of ink (e.g., the word blue in the ink color red) (Stroop, 1935). The primary component measured in the Stroop task is managing the conflict of incongruency between color and word meaning through inhibition (Miyake et al., 2000; Stroop, 1935). The primary area of the brain involved in the Stroop task appears to be the dorsolateral prefrontal cortex (DLPFC), which may have a role in executive functioning (Milham et al., 2003).

Anxiety and Stroop Task

Some evidence suggests that state anxiety does not negatively affect but may actually improve performance on the Stroop task (see Ursache & Cybele Raver, 2014). However, there is mixed evidence. Rosa-Alcázar et al. (2021) found that higher scores on a generalized anxiety disorder (GAD) screening survey were associated with worse performance on the Stroop color-word test. Another study found that participants who met the criteria for GAD performed worse than the "healthy" control group (Hallion et al., 2017). The authors suggested that the presence of GAD predicted deficits in performance on the Stroop task. This study's results could indicate how participants with high trait anxiety may perform on the Stroop task. Data suggests that trait anxiety may impair the DLPFC's role in attentional control while processing conflicting information (Bishop, 2009).

Furthermore, Heller et al. (1997) found that individuals with high levels of trait anxiety (anxious apprehension) seem to have asymmetry in the frontal lobes. These findings could be seen in decreased activity in the right frontal lobe, which may lead to possible deficits in executive functioning tasks (Heller et al.,1997; Milham et al., 2003). Finally, one study found a positive correlation between academic achievement and activation of brain areas responsible for strong performance on the Stroop task (Veroude et al., 2013), suggesting that if anxiety harms an individual's performance on the Stroop task, it may also adversely affect their academic performance (Hallion et al., 2017; Saviola et al., 2020; Veroude et al., 2013).

Methods

Participants

One hundred and seventeen undergraduate and graduate students from a large university in the southeast United States completed our study. Participants were recruited through SONA, word of mouth, email, and social media (e.g., Facebook, Instagram, and Reddit). Golden and Freshwater (2002) suggest a shift in Stroop scores after the age of 25, so all participants were between 18-25. We also only included participants who completed every item of the anxiety scale and both attention tasks. This study was approved by Middle Tennessee State University's institutional review board, and all participants provided informed consent.

Of our 117 participants, 24 identified as male, 81 identified as female, 10 identified as non-binary or a third gender, and two preferred not to say. In the sample, 92 participants identified as white, 13 participants as Hispanic or Latino, 13 participants as Black or African American, four participants as Asian, one participant as Native Hawaiian or Pacific Islander, eight participants as mixed ethnicity, and four as Other Ethnicity. Participants also reported previous anxiety diagnoses. There were 27 GAD diagnoses, 13 unspecified anxiety diagnoses, seven social anxiety disorder diagnoses, six panic disorder diagnoses, two preferred not to say, and one agoraphobia diagnosis reported.

Additionally, 35 participants reported being prescribed medication for anxiety or attention-deficit/hyperactivity disorder, and one preferred not to say. 65 participants reported that they currently were or had previously received psychotherapy for anxiety or depression. Fifty-one participants reported having never received psychotherapy, and one preferred not to say. Lastly, 33 participants reported that they were currently taking prescribed or non-prescribed psychotropic medications, 18 participants reported a history of severe head injury (e.g., concussion, TBI), and 20 participants reported using recreational substances.

Measures

All data was collected using PsyToolkit, a browser-based data collection tool with a large collection of psychological tests. The program allows researchers to assemble these individual tasks, along with demographic questions, and distribute them virtually for cloud-based data collection (Stoet, 2010, 2017). Traditionally, reaction time data is collected via in-person testing methods; the gold standard for collecting this type of data is a program called E-prime 3.0, which does not have browser-based capabilities.

Kim et al. (2019) found a high degree of replicability in reaction time measurement between E-prime and PsyToolkit. No significant differences were observed in the response time results between the two, indicating that PsyToolkit is comparable to E-prime 3.0 for measuring reaction times (Kim et al., 2019). Using PsyToolkit allowed participants to complete the study without any in-person interaction, minimizing any chance of spreading COVID-19 and allowing us to distribute the study more widely. PsyToolkit meets the standards of data protection laws in Europe and is supported by SONA.

There is currently no available reliability and validity on the Navon and Stroop task as measured through PsyToolkit. However, other studies have used PsyToolkit to measure reaction times and inhibitory control (e.g., Invernizzi et al., 2022; Utamatanin & Pariwatcharakul, 2022). Other theses and dissertations have utilized PsyToolkit in studies measuring the Stroop task (e.g., Ackerman, 2022; Anjomshoae, 2022; Bertleff, 2022). While there is limited data on these tasks as measured on PsyToolkit, PsyToolkit was the best option for collecting the data needed, considering our available resources.

The State-Trait Anxiety Inventory (STAI) form Y was used to measure state anxiety (in the present moment) and trait anxiety (general sense of anxiety). The STAI is a 4-point Likert scale ranging from "not at all" to "very much so" (Spielberger et al., 1983). STAI-S is the state anxiety subscale, consisting of 20 items about "how you feel right now, at this moment," and STAI-T is the trait anxiety subscale also consisting of 20 items about "how you generally feel."

In a sample of undergraduate students, the internal consistency reliability for males on the STAI-S was α = 0.91, and on the STAI-T, α = 0.90. For females, STAI-S was α = 0.93, and for STAI-T, α = 0.91 (Spielberger, 1983). In a meta-analysis, Barnes et al. (2002) reported an average internal consistency for STAI Form Y of α = .92. In a sample of undergraduate students, Creamer et al. (1995) found moderate test-retest correlation coefficients between the STAI-T and the Beck Anxiety Inventory (r = .57 and .68), as well as the STAI-S with the Beck Anxiety Inventory (r = .56 and .64).

The Navon task measures participants' global and local processing. It was chosen because it has been used in previous literature on anxiety and global/local processing (Becker et al., 2017; Shilton et al., 2019). The Navon task measures response times and errors in processing global and local visual elements (Navon, 1977; Nayar et al., 2015). This task presents the participant with a global stimulus (i.e., a large letter). This global stimulus shape comprises many local stimuli (i.e., small letters). Participants are asked to decide if they see the target letters (H or O) on either the global level or the local level of the stimuli (Stoet, 2010, 2017; Navon, 1977).

The PsyToolkit version of the task consists of 50 trials: 12-13 global congruent trials, 12-13 local congruent trials, and 24-26 trials that have neither H nor O in either the global or local elements and consist of only other letters. Each global-level figure is seven local-element letters tall and five letters wide. For the Navon task, one study on undergraduate students had an average test-retest reliability using Pearson correlation coefficients r = .66 for global-level processing and r = .73 for local-level processing, which suggests acceptable reliability (Dale & Arnell, 2013).

First, participants viewed a screen with instructions and examples of congruent and incongruent trials, with no practice trials. Upon clicking through the instructions, the task began. During each trial, participants viewed a large letter composed of small letters. Participants had to indicate whether the figure contained the letters H or O by pressing a key. Participants pressed the "b" key if either of these letters were present, and the "n" key if neither letter was included in the figure.

Participants had 4000 milliseconds to respond. A green smiling face would flash on the screen to alert participants if they correctly identified an H or O appearing on either the global or local level of the figure, and a red frowning face would appear if the participant incorrectly identified an H or O appearing. If participants exceeded the time limit without a response, the word "slow" would appear on the screen, leading to the next trial.

The Stroop task was chosen for this study because it is widely used to measure executive skills and functioning (Rueda et al., 2016). The Stroop color-word task provided by PsyToolkit measures inhibition in executive control through response times. For this study, we exclusively used the color-word trials where the participant was asked to only respond to the color of the ink the word is in while ignoring its meaning. Participants were expected to ignore the word's meaning in this task and respond only to its color.

There were congruent (e.g., the word blue in the ink color blue) and incongruent trials (e.g., the word red in the ink color blue). The PsyToolkit version of the Stroop color-word task consists of 40 trials of the color-word Stroop task while ignoring the word's meaning, with 11-12 congruent trials and 28-29 incongruent trials. The task began with instructions and examples of congruent and incongruent trials, but there were no practice trials. Upon clicking through the instructions, the task began.

A fixation cross flashed on the screen for 250 milliseconds in these trials to direct the participant's attention. This was followed by the name of a color (blue, red, yellow, or green) in blue, red, yellow, or green ink flashing on the screen for 2000 milliseconds, during which the participants had to identify the color of the ink with a key press. The participant had to press the key on their keyboard that matched the corresponding color: b for blue, r for red, y for yellow, and g for green.

In each trial, the participant had to respond within 2000 milliseconds. If they chose the incorrect key or exceeded the time limit, the word "wrong" would appear on the screen, leading to the next trial. If they chose the correct key, the word "correct" would appear. One study using undergraduate students found retest reliability for the standard Stroop color-word task's congruent color-word $\alpha = .71$ ($p < .001$) and an incongruent color-word of $\alpha = .79$ ($p < .001$) (Strauss et al., 2005).

Procedures

To begin, the participants visited the URL and read the informed consent. After agreeing to participate, participants completed the state anxiety index of the STAI. Participants then completed both the Navon and Stroop tasks. We chose to put the state anxiety subscale before the two tasks to get as accurate a measurement of their current state as possible. We also chose to put the trait subscale after the tasks in an attempt to avoid inducing any additional anxiety in the participant.

The study was counterbalanced so that equal numbers of participants started with the Navon or the Stroop task. There were no breaks between the two tasks, with the next task following the completion of the first task. Upon completion of both tasks, the participants then completed the trait anxiety index of the STAI. This was followed by the collection of demographic information. Lastly, a debriefing statement appeared on screen thanking the participants for their participation and ending the experiment.

Results

Analysis Summary

All the data was analyzed using Jamovi (Version 2.4.1). Participants were split into low and high anxiety groups by their mean scores on the STAI-S and STAI-T subscales for each task. In the Navon task, we divided participants into a low trait anxiety group and a high trait anxiety group using a mean split of the STAI-T scores. We conducted a t-test to compare median response times on global congruent trials between participants with high and low trait-anxiety. We used the same method to compare the two groups' response times for local congruent trials. For the Stroop task, we divided participants into four groups based on state and trait anxiety. We conducted an ANOVA to compare response times on incongruent trials across the four groups.

State-Trait Anxiety Inventory

We calculated each participant's state anxiety scores (STAI-S) and trait anxiety scores (STAI-T). Scores were calculated by summing the Likert responses (valued one to four) on each 20-item subscale, with some items being reverse-coded per the STAI manual (Spielberger et al., 1983). For each subscale (STAI-T, STAI-S), scores can range from 20 to 80. In the original normative data, their college sample was split into male and female groups. The male group's average score on the state subscale was ($M = 36.47$, $SD = 10.52$), and the female group's average score on the state subscale was ($M = 38.76$, $SD = 11.07$). The average male score on the trait subscale was ($M = 38.30$, $SD = 8.88$), and the average female score on the trait subscale was ($M = 40.40$, $SD = 9.31$) (Spielberger et al., 1983).

In our study, participants' scores on each subscale of the STAI were used to create a mean split to divide participants into high and low trait anxiety and high and low state anxiety groups as indicated. Participants' state anxiety subscale scores ($N = 117$, $M = 45.56$, $SD = 11.78$) were normally distributed, slightly skewed right with a .20 skewness, and platykurtic with kurtosis of -.73. Trait anxiety ($N = 117$, $M = 51.74$, $SD = 11.91$) was normally distributed, slightly skewed left with a -.21 skewness, and platykurtic with kurtosis of -.42.

Navon Task

Reaction times in each trial were measured in milliseconds, with a notation of whether the trial was a local or global congruent task. We calculated the median reaction time for each participant for global and local trials. We then divided participants into high-trait and low-trait anxiety groups using a mean split on their STAI-T scores. We calculated a mean global and local reaction time based on the median scores for each group and compared them using one-tailed t-tests.

We conducted a t-test on median global processing response times in milliseconds, comparing low and high trait anxiety groups to address our first hypothesis. We hypothesized that participants with high trait anxiety would have slower reaction times on global processing than those with low trait anxiety. Equality of variance was assumed $F_{(1,115)} = 0.979$. We did not find a statistically significant difference, $t_{(115)} = -0.09$, $p = .464$, $d = -0.02$ between our low trait anxiety ($N = 58$, $M = 828.67$, $SD = 171.97$) and high trait anxiety ($N = 59$, $M = 831.60$, $SD = 180.98$) groups in reaction times on global trials.

We also conducted a t-test on median local processing response times in milliseconds, comparing low trait and high trait anxiety groups to address our second hypothesis. We hypothesized that participants with high trait anxiety would have faster reaction times on local processing than low trait anxiety participants. Equality of variance was assumed, $F_{(1,115)} = .660$. We did not find a statistically significant difference, $t_{(115)} = -1.15$, $p = .127$, $d = -0.21$ between our low trait anxiety ($N = 58$, $M = 815.78$, $SD = 179.60$) and our high trait anxiety ($N = 59$, $M = 861.09$, $SD = 242.95$) groups in reaction times on local trials.

Stroop Task

Lastly, we conducted a one-way ANOVA between the low state/low trait group (LL) ($N = 43$, $M = 927.70$, $SD = 180.87$), high state/low trait (HL) ($N = 15$, $M = 1021.40$, $SD = 225.63$), low state/high trait (LH) ($N = 22$, $M = 923.91$, $SD = 177.71$), and high state high trait group (HH) ($N = 37$, $M = 942.38$, $SD = 162.84$) on median Stroop incongruent trials. We did not find a statistically significant difference between groups, $F_{(3, 113)} = 1.12$, $p = .344$. This addressed our last hypothesis, that the three groups of anxiety (HL, LH, and HH) would have slower reaction times on the incongruent trials of the Stroop task when compared to the control group (LL).

Discussion

This study explored the possible interactions between state and trait anxiety and attention in college students through performance on versions of the Navon and Stroop tasks available on PsyToolkit (Stoet, 2010, 2017). We measured the relationship of trait anxiety with global and local processing using the Navon task. We also measured the relationship between state anxiety and trait anxiety on cognitive inhibition of executive control through the Stroop task. We did not find statistically significant results to support our three hypotheses: there was no association found between anxiety and performance on either task in this study.

Anxiety and Global/Local Processing

We hypothesized that participants with high trait anxiety would have slower reaction times on global processing trials than those with low trait anxiety. Additionally, based on previous findings, we hypothesized that participants with high trait anxiety would have faster reaction times on local processing trials than low-anxiety participants. However, our results showed no significant differences between groups on either task. Some evidence suggests the lack of a finding in our global processing t-test is not surprising (Shilton et al., 2019). There is considerable evidence from previous literature for our local processing hypothesis (Basso et al., 1996; Becker et al., 2017; Derryberry & Reed, 1998; Shilton et al., 2019).

Interestingly, although not statistically significant, our results went in the opposite direction of what was hypothesized for local processing: on average, for global trials, low trait anxiety participants ($M = 828.67$) had slightly faster reaction times than high trait anxiety participants ($M = 831.60$). For local trials, the high trait anxiety participants ($M = 861.09$) had slightly slower reaction times than those with low trait anxiety ($M = 815.78$). Our high trait anxiety participants did not display a local processing bias.

Variations between our design and previous studies may explain our findings (e.g., online study or having specific target letters). Some of the previous literature used different global and local processing paradigms (Basso et al., 1996; Shilton et al., 2019). Other variables could also explain the observed results, including variability due to uncontrolled testing environments, as participants completed the study online with no restrictions about the type of location where they completed the tasks.

There is a need to further investigate global and local processing in college samples. In a sample of undergraduate students, Tan et al. (2017) found evidence that their participants were more willing to take academic risks when globally primed than participants who were locally primed. This willingness to take more significant risks in an educational setting could lead to greater academic achievement. To our knowledge, the literature on global and local processing and academic success is sparse. One study used a global and local processing paradigm to predict academic achievement. However, this study focuses on meta-motivation, and it was unclear how global and local processing affect academic achievement (Nguyen et al., 2023).

Another study found that in children with attention-deficit/hyperactivity disorder, the ability to shift between global and local stimuli was predictive of academic achievement. (Sjöwall & Thorell, 2014). In that same study, inhibition was also predictive of academic achievement (Sjöwall & Thorell, 2014). Additionally, the ability to efficiently process one's visual environment on the global level appears to be beneficial in understanding written communication (Woltin et al., 2012). This may translate to the ability to understand the information in a textbook while studying, suggesting that if anxiety does decrease global processing, high trait anxiety could impair reading ability while studying (Basso et al., 1996).

Anxiety and Stroop Task

We hypothesized that the HL group (M = 1021.40), LH group (M = 923.91), and the HH group (M = 942.38) would have slower reaction times on the incongruent trials of the Stroop task when compared to the LL group (M = 927.70). We found no significant impact of anxiety on response inhibition. Our groups' distributions may have contributed to our observed results (see Limitations for a more in-depth discussion). It is important to continue investigating how various factors influence executive attention. Studies have found a correlation between executive functioning and academic achievement from early childhood through college (Baars et al., 2015; Best et al., 2011).

Limitations

This study had several limitations, one of which was group dispersion. For our ANOVA, we would have preferred to have roughly 25 participants in each of our four groups. Instead, we had 43 participants in our LL group, 15 participants in our HL group, 22 participants in our LH group, and 37 participants in our HH group. This lack of dispersion may have prevented our groups from varying enough to observe any notable differences.

Collectively, our average STAI scores were roughly a standard deviation above the original normative sample (Spielberger et al., 1983). This may have contributed to a lack of lower levels of anxiety. Another limitation is the fact that we measured state anxiety without any stress induction or any way to control it. This caused us to rely on participants already being in an anxious state when creating our groups.

The average age of participants in our study was only 19.85. Previous studies had participants ranging in age from 17 to 71. Many previous studies used participants with a wider range of ages; it is possible that age may contribute to the discrepancies between those studies and our results (Hallion et al., 2017; Pacheco-Unguetti et al., 2010; Rosa-Alcázar et al., 2021). Our study may better represent anxiety's effect on predominantly white college students between the ages of 18-25, but it may not be generalizable to other demographics or the general population. Preferably, we would have recruited more participants to allow us to exclude additional factors that may have affected their performance, such as the use of psychotropic medication, psychotherapy, and past head injury (e.g., traumatic brain injury, concussion).

As previously mentioned, the study was conducted entirely online, which limits our control of participants' machines and testing environments. Additionally, PsyToolkit versions of both tasks required the use of key inputs. This motor input might have unintentionally activated areas of the brain (Cramer et al., 1999), which would ultimately add additional variability. Despite this, Hallion et al. (2017) also used a computer-adapted version of the Stroop task and found evidence suggesting that the presence of GAD predicted Stroop task results. Previous studies that used the traditional Stroop Color Word Test design with word trials and color trials may also contribute to the observed differences (Hallion et al., 2017; Rosa-Alcázar et al., 2021).

The PsyToolkit version of the Stroop task required four different keystrokes, which might have made the task more confusing and possibly measured more than response inhibition. Additionally, we eliminated timed-out and incorrect trials, where the traditional Stroop Color Word Test asks the test taker to retry the item as the timer goes down. Our method requires the test taker to inhibit their response to every trial correctly. Differences between versions of the task may influence observed performance. We also used versions of these tasks that do not have normative data. Finally, we had more women in our high anxiety group than our low anxiety group, which could possibly impact scores.

Additionally, having a higher percentage of males in our low anxiety groups may have had an impact on the observed results. Males and females are known to have neural structural differences (Ingalhalikar et al., 2013). Specifically, findings in other visual perception tasks that target the right parietal lobe show a difference in performance between males and females (Kalichman, 1988; Linn & Petersen, 1985). Given this, our findings on global processing, which targets the right parietal lobe, may be affected by gender differences between groups (Kimchi & Merhav, 1991).

Future Directions

In the future, studies should examine other areas we did not address, such as socioeconomic status, culture, or gender-related differences that may contribute to individual differences on these tasks. Future studies examining how emotions, mood, and anxiety may contribute to deficits in attention should consider a more general and comprehensive battery, such as tasks designed to measure the other two neural networks of attention, proposed by Posner and Petersen (1990) (alerting and orienting). In this study, only one aspect of executive attention was measured, which was response inhibition.

There are other parts of executive functioning and other tasks that measure these aspects (e.g., Tower of London, Trail Making Test, and Wisconsin Card Sorting Test) that could be used for future research (Etnier & Chang, 2009). Future studies comparing all-male to all-female participants may be beneficial in observing whether there are any gender differences in these tasks as measured by PsyToolkit. PsyToolKit is a free and readily available resource for psychological testing. This makes it ideal for use by students and others with limited funding and resources. Therefore, it is crucial to establish normative values and ecological validity for these specific versions of each task, which would enable future research and possibly clinical applications.

Conclusion

Our three hypotheses that global processing, local processing, and response inhibition would be impacted by elevated levels of anxiety were not supported. The results of this project are inconsistent with previous findings (Basso et al., 1996; Becker et al., 2017; Derryberry & Reed, 1998; Hallion et al., 2017; Pacheco-Unguetti et al., 2010; Rosa-Alcázar et al., 2021; Shilton et al., 2019). Anxiety symptoms appear prevalent in college students, and academic achievement has been observed as one of the most significant stressors in a student's life (Asher BlackDeer et al., 2021; Beiter et al., 2015).

Additionally, while not replicated in this study, there is previous literature that suggests anxiety can harm not only attention but academic achievement, as well (Basso et al., 1996; Cassady & Johnson, 2002; Hoegler & Nelson, 2018; Pacheco-Unguetti et al., 2010; Rosa-Alcázar et al., 2021; Vitasari et al., 2010). Literature suggests that better performance on the tasks used in this study can predict academic achievement.

Future studies are needed to address the uncertainty of the effects state anxiety may have on the Stroop task, as there are mixed findings and conflicting theories about whether state anxiety is beneficial or detrimental to executive functioning (Eysenck et al., 2007; Pacheco-Unguetti et al., 2010; Ursache & Cybele Raver, 2014). Furthermore, future studies should continue to analyze the potential benefits of using software similar to PsyToolkit as a substitute for collecting data in a laboratory setting. Similarly, the clinical utility of online-based data collection of inhibitory control, global processing, and local processing should also be addressed in future research. Overall, our study did not find any statistically significant differences in the effect of anxiety on attention as measured by these two tasks. This study provides a valuable understanding of how state and trait anxiety affect performance on these two tasks as measured by PsyToolkit (Stoet, 2010, 2017) in this specific sample of students at Middle Tennessee State University.

References

Ackerman, S. (2022). *COVID-19 and Executive Functions*. [Bachelor's thesis, Eastern Kentucky University]

Albert, J., López-Martín, S., Hinojosa, J. A., & Carretié, L. (2013). Spatiotemporal characterization of response inhibition. *NeuroImage, 76*, 272-281. https://doi.org/10.1016/j.neuroimage.2013.03.011

Anjomshoae, F. (2022). *Testing Effects of Bilingualism on Inhibition, Shifting and Working Memory Ability in Adults*. [Master's thesis, University of Alberta]

Asher BlackDeer A., Patterson Silver Wolf D.A., Maguin E., & Beeler-Stinn S. (2023). Depression and anxiety among college students: Understanding the impact on grade average and differences in gender and ethnicity. *Journal of American College Health, 71*(4), 1091-1102. https://doi.org/10.1080/07448481.2021.1920954

Baars, M. A., Nije Bijvank, M., Tonnaer, G. H., & Jolles, J. (2015). Self-report measures of executive functioning are a determinant of academic performance in first-year students at a university of applied sciences. *Frontiers in Psychology, 6*, 1131. https://doi.org/10.3389/fpsyg.2015.01131

Banich, M. T., Milham, M. P., Atchley, R., Cohen, N. J., Webb, A., Wszalek, T., Kramer, A., Liang, Z., Wright, A., Shenker, J., & Magin, R. (2000). fMRI studies of Stroop tasks reveal unique roles of anterior and posterior brain systems in attentional selection. *Journal of Cognitive Neuroscience, 12*(6), 988-1000. https://doi.org/10.1162/08989290051137521

Barnes, L. L., Harp, D., & Jung, W. S. (2002). Reliability generalization of scores on the Spielberger state-trait anxiety inventory. *Educational and Osychological Measurement, 62*(4), 603-618. https://doi.org/10.1177/0013164402062004005

Basso, M., Schefft, B., Ris, M., & Dember, W. (1996). Mood and global-local visual processing. *Journal of the International Neuropsychological Society, 2*(3), 249-255. https://doi.org/10.1017/S1355617700001193

Becker, K. R., Plessow, F., Coniglio, K. A., Tabri, N., Franko, D. L., Zayas, L. V., Germine, L., Thomas, J. J., & Eddy, K. T. (2017). Global/local processing style: Explaining the relationship between trait anxiety and binge eating. *International Journal of Eating Disorders, 50*(11), 1264–1272. https://doi.org/10.1002/eat.22772

Beiter, R., Nash, R., McCrady, M., Rhoades, D., Linscomb, M., Clarahan, M., & Sammut, S. (2015). The prevalence and correlates of depression, anxiety, and stress in a sample of college students. *Journal of Affective Disorders, 173*, 90–96. https://doi.org/10.1016/j.jad.2014.10.054

Bertleff, A. J. (2022). *Automaticity in Musicians as Demonstrated by a Modified Stroop Task* [Doctoral dissertation, Kent State University].

Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations between executive function and academic achievement from ages 5 to 17 in a large, representative national sample. *Learning and Individual Differences, 21*(4), 327-336. https://doi.org/10.1016/j.lindif.2011.01.007

Bishop, S. J. (2009). Trait anxiety and impoverished prefrontal control of attention. *Nature Neuroscience, 12*(1), 92-98. https://doi.org/10.1038/nn.2242

Cassady, J. C., & Johnson, R. E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology, 27*(2), 270-295. https://doi.org/10.1006/ceps.2001.1094

Chaplin, T., (1989). The relationship of trait anxiety and academic performance to achievement anxiety: students at risk. *Journal of College Student Development, 30*, 229-236.

Chew, P. K. H., & Dillon, D. B. (2014). Statistics anxiety update: Refining the construct and recommendations for a new research agenda. *Perspectives on Psychological Science, 9*(2), 196–208. https://doi.org/10.1177/1745691613518077

Cramer, S. C., Finklestein, S. P., Schaechter, J. D., Bush, G., & Rosen, B. R. (1999). Activation of distinct motor cortex regions during ipsilateral and contralateral finger movements. *Journal of Neurophysiology, 81*(1), 383-387. https://doi.org/10.1152/jn.1999.81.1.383

Creamer, M., Foran, J., & Bell, R. (1995). The Beck Anxiety Inventory in a non-clinical sample. *Behaviour Research and Therapy, 33*(4), 477-485. https://doi.org/10.1016/0005-7967(94)00082-U

Dale, G., & Arnell, K. M. (2013). Investigating the stability of and relationships among global/local processing measures. *Attention, Perception, & Psychophysics, 75*, 394-406. https://doi.org/10.3758/s13414-012-0416-7

Derryberry, D., & Reed, M. A. (1998). Anxiety and attentional focusing: Trait, state and hemispheric influences. *Personality and Individual Differences, 25*(4), 745-761. https://doi.org/10.1016/S0191-8869(98)00117-2

Etnier, J. L., & Chang, Y. K. (2009). The effect of physical activity on executive function: a brief commentary on definitions, measurement issues, and the current state of the literature. *Journal of Sport and Exercise Psychology, 31*(4), 469-483. https://doi.org/10.1123/jsep.31.4.469

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion, 7*(2), 336. https://doi-org.ezproxy.mtsu.edu/10.1037/1528-3542.7.2.336

Hallion, L. S., Tolin, D. F., Assaf, M., Goethe, J., & Diefenbach, G. J. (2017). Cognitive control in generalized anxiety disorder: Relation of inhibition impairments to worry and anxiety severity. *Cognitive Therapy and Research, 41*(4), 610-618. https://doi.org/10.1007/s10608-017-9832-2

Heller, W., Nitschke, J. B., Etienne, M. A., & Miller, G. A. (1997). Patterns of regional brain activity differentiate types of anxiety. *Journal of Abnormal Psychology, 106*(3), 376. https://doi.org/10.1037/0021-843X.106.3.376

Hoegler, S., & Nelson, M. (2018). The Influence of anxiety and self-efficacy on statistics performance: A path analysis. *Psi Chi Journal of Psychological Research, 23*(5). https://doi.org/10.24839/2325-7342.JN23.5.364

Ingalhalikar, M., Smith, A., Parker, D., Satterthwaite, T. D., Elliott, M. A., Ruparel, K., Hakonarson, H., Gur, R., Gur, R., & Verma, R. (2014). Sex differences in the structural connectome of the human brain. *Proceedings of the National Academy of Sciences, 111*(2), 823-828. https://doi.org/10.1073/pnas.1316909110

Invernizzi, P. L., Rigon, M., Signorini, G., Colella, D., Trecroci, A., Formenti, D., & Scurati, R. (2022). Effects of varied practice approach in physical education teaching on inhibitory control and reaction time in preadolescents. *Sustainability, 14*(11), 6455. https://doi.org/10.3390/su14116455

Kalichman, S. C. (1988). Individual differences in water-level task performance: A component-skills analysis. *Developmental Review, 8*(3), 273-295. https://doi.org/10.1016/0273-2297(88)90007-X

Kim, J., Gabriel, U., & Gygax, P. (2019). Testing the effectiveness of the Internet-based instrument PsyToolkit: A comparison between web-based (PsyToolkit) and lab-based (E-Prime 3.0) measurements of response choice and response time in a complex psycholinguistic task. *PloS one, 14*(9), e0221802. https://doi.org/10.1371/journal.pone.0221802

Kimchi, R., & Merhav, I. (1991). Hemispheric processing of global form, local form, and texture. *Acta Psychologica, 76*(2), 133–147. https://doi.org/10.1016/0001-6918(91)90042-x

Kosslyn, S. M., Brown, H. D., & Dror, I. E. (1999). Aging and the scope of visual attention. *Gerontology, 45*(2), 102-9. https://doi.org/10.1159/000022071

Linn, M. C., & Petersen, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development, 56*(6), 1479-1498. https://doi.org/10.2307/1130467

Milham, M. P., Banich, M. T., Claus, E. D., & Cohen, N. J. (2003). Practice-related effects demonstrate complementary roles of anterior cingulate and prefrontal cortices in attentional control. *Neuroimage, 18*(2), 483-493. https://doi.org/10.1016/S1053-8119(02)00050-2

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Najmi, S., Kuckertz, J. M., & Amir, N. (2012). Attentional impairment in anxiety: inefficiency in expanding the scope of attention. *Depression and Anxiety, 29*(3), 243-249. https://doi.org/10.1002/da.20900

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology, 9*(3), 353–383. https://doi.org/10.1016/0010-0285(77)90012-3

Nayar, K., Franchak, J., Adolph, K., & Kiorpes, L. (2015). From local to global processing: the development of illusory contour perception. *Journal of Experimental Child Psychology, 131*, 38–55. https://doi.org/10.1016/j.jecp.2014.11.001

Nguyen, T., Scholer, A. A., Miele, D. B., Edwards, M. C., & Fujita, K. (2023). Predicting academic performance with an assessment of students' knowledge of the benefits of high-level and low-level construal. *Social Psychological and Personality Science, 14*(2), 195-206. https://doi.org/10.1177/19485506221090051

Owens, M., Stevenson, J., Hadwin, J. A., & Norgate, R. (2012). Anxiety and depression in academic performance: An exploration of the mediating factors of worry and working memory. *School Psychology International, 33*(4), 433-449. https://doi.org/10.1177/0143034311427433

Pacheco-Unguetti, A. P., Acosta, A., Callejas, A., & Lupiáñez, J. (2010). Attention and anxiety: Different attentional functioning under state and trait anxiety. *Psychological science, 21*(2), 298-304. https://doi.org/10.1177/0956797609359624

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13*(1), 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Posner, M.I., Rueda, M.R., & Kanske, P. (2007). Probing the mechanisms of attention. In J.T. Cacioppo, J.G. Tassinary & G.G. Berntson (eds), *Handbook of Psychophysiology*, Third Edition. Cambridge U.K.: Cambridge University Press (pp 410-432).

Rosa-Alcázar, A. I., Rosa-Alcázar, Á., Martínez-Esparza, I. C., Storch, E. A., & Olivares-Olivares, P. J. (2021). Response Inhibition, Cognitive Flexibility and Working Memory in Obsessive-Compulsive Disorder, Generalized Anxiety Disorder and Social Anxiety Disorder. *International Journal of Environmental Research and Public Health, 18*(7), 3642. https://doi.org/10.3390/ijerph18073642

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2016). The development of executive attention: Contributions to the emergence of self-regulation. In *Measurement of Executive Function in Early Childhood* (pp. 573-594). Psychology Press.

Saviola, F., Pappaianni, E., Monti, A., Grecucci, A., Jovicich, J., & De Pisapia, N. (2020). Trait and state anxiety are mapped differently in the human brain. *Scientific Reports, 10*(1), 1-11. https://doi.org/10.1038/s41598-020-68008-z

Shilton, A. L., Laycock, R., & Crewther, S. G. (2019). Different effects of trait and state anxiety on global-local visual processing following acute stress. Cognition, Brain, Behavior. *An Interdisciplinary Journal, 23*(3), 155–170. https://doi.org/10.24193/cbb.2019.23.09

Sjöwall, D., & Thorell, L. B. (2014). Functional impairments in attention deficit hyperactivity disorder: the mediating role of neuropsychological functioning. *Developmental Neuropsychology, 39*(3), 187-204. https://doi.org/10.1080/87565641.2014.886691

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Stoet, G. (2010). PsyToolkit - A software package for programming psychological experiments using Linux. *Behavior Research Methods, 42*(4), 1096-1104. https://doi.org/10.3758/BRM.42.4.1096

Stoet, G. (2017). PsyToolkit: A novel web-based method for running online questionnaires and reaction-time experiments. *Teaching of Psychology, 44*(1), 24-31. https://doi.org/10.1177/0098628316677643

Strauss, G. P., Allen, D. N., Jorgensen, M. L., & Cramer, S. L. (2005). Test-retest reliability of standard and emotional Stroop tasks: an investigation of color-word and picture-word versions. *Assessment, 12*(3), 330-337. https://doi.org/10.1177/1073191105276375

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*(6), 643-662. https://doi.org/10.1037/h0054651

Tan, E. W., Lim, S. W. H., & Manalo, E. (2017). Global-local processing impacts academic risk taking. *Quarterly Journal of Experimental Psychology, 70*(12), 2434-2444. https://doi.org/10.1080/17470218.2016.1240815

Tsujimoto, S. (2008). The prefrontal cortex: Functional neural development during early childhood. *The Neuroscientist, 14*(4), 345-358. https://doi.org/10.1177/1073858408316002

Tyler, S. K., & Tucker, D. M. (1982). Anxiety and perceptual structure: individual differences in neuropsychological function. *Journal of Abnormal Psychology, 91*(3), 210. https://doi-org.ezproxy.mtsu.edu/10.1037//0021-843x.91.3.210

Ursache, A., & Raver, C. C. (2014). Trait and state anxiety: Relations to executive functioning in an at-risk sample. *Cognition & Emotion, 28*(5), 845-855. https://doi.org/10.1080/02699931.2013.855173

Utamatanin, N., & Pariwatcharakul, P. (2022). The Effect of Caffeine and Sleep Quality on Military Pilot Students' Flight Performance-Related Cognitive Function. *The International Journal of Aerospace Psychology, 32*(2-3), 152-164. https://doi.org/10.1080/24721840.2022.2034505

Veroude, K., Jolles, J., Knežević, M., Vos, C. M., Croiset, G., & Krabbendam, L. (2013). Anterior cingulate activation during cognitive control relates to academic performance in medical students. *Trends in Neuroscience and Education, 2*(3-4), 100-106. https://doi.org/10.1016/j.tine.2013.10.001

Vitasari, P., Wahab, M. N. A., Othman, A., Herawan, T., & Sinnadurai, S. K. (2010). The relationship between study anxiety and academic performance among engineering students. *Procedia-Social and Behavioral Sciences, 8*, 490-497. https://doi.org/10.1016/j.sbspro.2010.12.067

Woltin, K. A., Corneille, O., & Yzerbyt, V. Y. (2012). Improving communicative understanding: The benefits of Global Processing. *Journal of Experimental Social Psychology, 48*(5), 1179–1182. https://doi.org/10.1016/j.jesp.2012.03.004