

Factors underlying anxiety and how self-control contributes to emotion regulation in adolescence

Jinzhi Zhang *

Beijing National Day School, Beijing, China

* Corresponding Author Email: natejz@sina.com

Abstract. Adolescence is a critical developmental stage marked by significant emotional and cognitive changes, often leading to increased anxiety. This study investigates the relationship between self-control, executive functions, and anxiety in adolescents through a series of experiments. First, a comprehensive questionnaire was administered to assess anxiety levels across various life domains, including family life, school environment, and academic pressure. Second, a Stroop task was used to measure selective attention and cognitive interference, key components of executive function. Third, an emotion-based memory task explored how emotional content affects memory performance, with a focus on the influence of anxiety on emotional memory processing. Results showed a strong correlation between self-control and anxiety, with higher anxiety levels leading to poorer performance in tasks requiring attention control and emotional memory. These findings suggest that training executive functions, particularly selective attention and emotional regulation, could be an effective intervention for reducing anxiety in adolescents. The study underscores the importance of self-control mechanisms in managing emotional challenges during adolescence.

Keywords: Adolescence; anxiety; self-control; executive functions.

1. Introduction

Adolescence is a transformative period marked by significant physical, emotional, and social changes. It is also a life period most easily affected by the environmental problems caused by outer factors, such as those from a biological and social perspective. Firstly, teenagers' brains are at a critical stage of development, especially the prefrontal region, which is known to be essential for cognitive functions. Furthermore, hormonal changes of adolescence can significantly impact mood and emotions. Secondly, teenagers are in a critical period of self-development. However, rather than solely pursuing their self-identity, they often find themselves as the focal point of their family, receiving excessive attention or intervention from family members. This dynamic can conflict with their personal plans and aspirations, potentially leading to emotional issues. Thirdly, teenagers, being seen as the future of society, face higher general expectations compared to previous generations. This, again, might cause further pressure to the mental health of teenagers.

The stressors mentioned above have a large impact on teenagers, as a consequence, adolescents are more prone to depression, anxiety disorder, and other types of psychiatric disorders. In China, the prevalence of anxiety disorders among school students is 4.7%, with Generalized Anxiety Disorder (GAD) being the most common subtype at 1.3%. Anxiety disorders are widespread among students and often coexist with attention deficit and disruptive disorders, likely due to their limited emotional regulation capabilities. This issue could have broader societal impacts, such as threats to public safety, a shortage of workers, and hindrances to economic growth. To mitigate these potential negative effects, enhancing emotional control through executive function training may be beneficial. Researchers are exploring self-regulation and emotional control in teenagers to understand the mechanisms of executive functions during adolescence [1]. Individuals who experience anxiety normally would show physiological responses such as increasing the heart rate, breathing, and muscle tension. This is because of a high level of cortisol and adrenaline in the blood flow, as a consequence of the 'fight' or 'flight' signal sent from the amygdala in the central nervous system.

Irregulating emotions such as anxiety-like symptoms may be detrimental to the development of adolescents. Therefore, it is important to conduct interventions and understand the mechanisms

behind emotion regulation. In the past few years, there has been increasing communication between cognitive, social, and emotion research on how adolescents manage the pursuit of important long-term goals in the face of tempting alternatives. The research on self-regulation has benefitted enormously from the application of concepts and experimental paradigms from cognitive control research. Similarly, cognitive research may be inspired by the diverse ways in which social research has approached issues such as the study of situational and dispositional risk factors, multiple goal conflicts, and affect regulation, with the research program on depletion aftereffects being an excellent example for such an exchange [2]. Several open questions remain unexplored, and it is our hope that this project will further stimulate conversation between subdisciplines interested in self-regulation and the well-being of teenagers.

In this project, we aim to focus on the factors underlying anxiety in teenagers and to explore the mechanisms underlying self-control through psychophysical tasks. Here, we use questionnaire investigations in combination with psychology experiments performed by PsychoPy on adolescent participants to test our hypotheses, as detailed in subsequent sections.

2. Theories on Executive Functions

Adolescence is a period of increased risk for developing anxiety and depression. During the adolescence period, a time marked by emotional difficulties and the maturation of neural circuits involved in regulation, individuals may encounter a high risk of the onset of anxiety and depressive disorders [3]. Stressful life events and childhood adversity are well-known risk factors for future mental health issues, and evidence suggests that the ability to regulate emotional responses to these events can mediate this risk. With the increased independence and new challenges faced during adolescence, effective emotion regulation becomes crucial. Failure to manage emotions may heighten the risk of mental health problems. Studies have shown that individuals with anxiety disorders exhibit impairments in inhibitory control tasks compared to healthy controls, and inhibitory control is one aspect of executive functions (see further explanations below). Inhibitory control, a key component of executive functions, refers to the ability to manage attention, behavior, thoughts, and emotions to override a powerful internal urge or external temptation, and instead choose the more suitable or necessary action.

In laboratory tasks, young children often hurry to respond, leading to mistakes by providing the most automatic response instead of the one that is needed. Allowing children to take more time to respond enhances their performance. When an incorrect automatic response is triggered by a stimulus, individuals can be guided to respond correctly by hiding the stimulus, thus reducing or removing the need for inhibitory control. For instance, in Piaget's conservation test, where the liquid is poured into beakers of different shapes, children aged 4 to 5 often think there is more liquid in the taller beaker due to its perceptual pull. [4]. However, if they are not shown the different liquid levels and are instead asked which beaker has more liquid, they are more likely to answer correctly [5].

The definitions of executive functions are a set of cognitive processes that are essential for managing and regulating various higher-order cognitive functions involving inhibition, selective attention, task switching, and goal changing. There is general agreement that there are three core executive functions (e.g., [6, 7]): inhibition [inhibitory control, including self-control (behavioral inhibition) and interference control (selective attention and cognitive inhibition)], working memory (WM), and cognitive flexibility (also called set shifting, mental flexibility, or mental set shifting).

The components of cognition mentioned above are directly related to the process of self-control. It is known that the components of executive functions are closely linked to prefrontal regions in the brain. For example, as a system hub of self-control, the development of the prefrontal region continues to become mature as one grows from childhood and reaches its peak only during early adolescence. This biological factor may also serve as a potential risk for adolescents to be prone to emotional and self-control challenges. When the process of self-control becomes vulnerable, which is especially

common in teenagers, it may lead to emotional problems. The inhibition mechanism in the executive functions can help adolescents inhibit negative feelings or thoughts that irritate them. In addition, the goal-changing mechanism might endow a high level of flexibility for adolescents to break large task goals into smaller goals that are more achievable [8].

However, when they fail, individuals may encounter not only a loss of control of their emotions, but also frustrations from incompleteness of their tasks. This is evident in people who suffer from mental health issues such as anxiety disorders. Anxiety disorders can lead to difficulties in inhibiting irrelevant or intrusive thoughts and behaviors. Since there are abundant interactions between the prefrontal regions and a central emotional region – the amygdala, it is possible that emotional control is largely dependent on the normal functioning of the prefrontal regions.

Previous research has been using psychophysical task paradigms to measure the ability of self-control, focusing on cognitive functions including selective attention and working memory. Whereas selective attention involves basically the attention on a typical subject and the ignorance of another. Working memory is the method to help attain better self-control. One classical task of selective attention is the Stroop Test. Developed by John Ridley Stroop in the 1930s, this task has evolved into a fundamental instrument for investigating cognitive biases related to emotions. Its influence extends across various domains, including clinical psychology, cognitive neuroscience, and affective computing, offering valuable insights into human behavior and cognition. Its variant, The Emotional Stroop Task, stands as a pivotal tool in psychological research, shedding light on the intricate mechanisms underlying emotion processing [9]. For example, research using Stroop tasks has demonstrated decreased performance in inhibitory control among individuals with anxiety disorder [8].

Research into reliable psychophysiological markers of emotion regulation in adolescents has aimed to pinpoint specific disruption patterns associated with anxiety and depression. A study involving anxious youth [10] found that individuals with anxiety disorders had more fixations on both negatively and positively charged images compared to neutral ones, in contrast to healthy individuals. The above describes what is known so far about people experiencing anxiety disorders and other situations that mainly depend on the ability of self-control.

Computer-based methods for assessing emotion regulation typically involve showing participants emotionally charged images like those from the International Affective Picture System [11] and asking them to rate their emotional reactions. More effective ‘deliberate regulation’ designs compare passive ‘reactivity’ trials with active ‘regulatory’ trials, where participants are instructed to adjust their emotional responses, allowing for a within-subjects analysis of the impact of intentional emotion regulation strategies. Research shows that anxious adolescents have increased emotional reactivity to negative images and experience difficulties in reappraisal when cued [12]. However, in trials where they successfully engage in reappraisal, anxious adolescents are able to effectively reduce their negative affect to a degree similar to that of non-anxious adolescents.

Previous studies have typically used questionnaires to measure the cognitive functions of Chinese adolescents. However, few studies have employed cognitive experiments like the Stroop paradigm to assess cognitive control in this population. The latter method can more objectively reflect the true situation of adolescents and reduce the influence of social desirability biases. In the current project, we propose that tasks of executive functions may act as potential candidates for measurement and training of emotion regulation and capacity of self-control.

3. Hypotheses

3.1. First hypothesis: the capacity for self-control in individuals might be linked to their susceptibility to anxiety disorders.

Research suggests that levels of selective attention, which can be assessed through tasks like the Stroop test, may differ among groups of teenagers who exhibit anxiety or stress-related symptoms. Specifically, variations in accuracy—such as the rate of correct responses versus missed ones—and

reaction time, or the latency of their choices, might reflect these differences. To explore this, one could categorize participants based on their stress levels—high, intermediate, or low—using adolescent stress questionnaires. Additionally, incorporating emotion-related word items in these assessments could be beneficial. This approach would allow researchers to manipulate the level of selective attention and self-control in relation to both the semantic meaning and sensory features of the stimuli, providing deeper insights into how self-control capacity might influence vulnerability to anxiety disorders.

We propose that several factors can contribute to the onset of anxiety during adolescence, exacerbating the already tumultuous stage of development. First, academic pressures stemming from high expectations, competitive environments, and uncertainty about the future can induce significant stress. Social dynamics, including peer pressure, bullying, and feelings of social inadequacy, also play a pivotal role in triggering anxiety among teenagers. Additionally, hormonal changes during puberty can lead to emotional volatility and heightened sensitivity to stressors. Moreover, familial conflicts, such as parental expectations or discord, can create a tense home environment, further impacting a teenager's mental well-being. The pervasive influence of social media and technology introduces another layer of complexity, with constant comparison, cyberbullying, and the pressure to maintain an idealized online image contributing to anxiety. Amidst these challenges, inadequate coping mechanisms and a lack of support systems can exacerbate anxiety symptoms, making it crucial to address these multifaceted issues comprehensively.)

Furthermore, stress from society in general has been upgraded. For example, the population has been increasing but there are only small amounts of career places. Therefore, the competition for these resources has been fiercer and brings more stress. Also, teenagers have various social networks. This means that they are easily influenced by the people around them. Also, in their university, homework and essays increase their stress.

3.2. Second hypothesis: the capacity of self-control could be measured by cognitive assessments and linked to selective attention and memory recognition.

The potential relationship between self-control and anxiety suggests that enhancing self-control abilities could offer significant benefits, particularly in managing anxiety and related emotional issues. Selective attention-based tasks, such as visual search tasks or Posner's cueing task, may be able to involve active attentional shifts. These exercises train individuals to better direct their attention and focus, which can lead to a more concentrated and efficient performance in various tasks. If individuals can enhance their ability to actively shift their attention, they might experience a more focused state during task execution, potentially reducing anxiety and improving overall emotional regulation. To evaluate the potential of these cognitive tasks, researchers can use measurements of self-control ability such as Stroop task and memory-based tasks to assess self-control capacity and their potential implication in managing stress and emotional issues. Improved self-control through such cognitive training could, therefore, be instrumental in addressing and mitigating emotion-related challenges.

Engaging in cognitive tests and exercises using PsychoPy is valuable for exploring and enhancing cognitive functions, particularly executive functions and emotion regulation. PsychoPy's flexibility allows researchers to design tasks that probe various cognitive abilities and their relationships with emotional control.

First, to quantify and train the individual's ability in selective attention, we adopted the Stroop task, a widely used cognitive task in PsychoPy, specifically measures self-control and executive functions. It involves naming the ink color of words that spell out different colors, requiring participants to override the automatic tendency to read the word. This task assesses the ability to manage cognitive interference, which is a critical aspect of self-control. Successful performance reflects how well an individual can suppress an automatic response in favor of a goal-directed action.

Second, we designed an emotion-based memory recognition task to evaluate cognitive abilities related to the storage, retrieval, and manipulation of information specifically related to emotion processing. These tasks reveal aspects of working memory, episodic memory, and recall. Working

memory is particularly related to self-control, as it allows individuals to hold and manipulate information over short periods, which is crucial for making informed decisions and regulating behavior. Effective memory function supports self-control by enabling individuals to recall past experiences and apply learned strategies to current situations, thus aiding in emotional regulation and impulse management.

4. Experiment and Survey

We use the questionnaire to measure the level of anxiety in adolescence. To comprehensively assess an individual's well-being and its potential impact on their anxiety levels, various questionnaires can be utilized. First, personal health questionnaires would gauge physical and mental states, moods, and attitudes, evaluating whether individuals feel positive or negative and whether they experience energy or fatigue. Second, family life assessments would explore issues such as conflicts at home, family activities, boundaries between family members, and parental control over decisions. School life questionnaires would cover social interactions with peers, including leisure activities, social support, and peer pressure, as well as interactions with teachers and educators, focusing on the extra support received in areas like personal growth, emotional well-being, and maintaining a healthy campus environment. Additionally, these questionnaires would assess the freedom in leisure activities. Finally, evaluations of future uncertainty and academic pressure would address goal achievement, including awards and school performance, as well as the pressure related to tests. This comprehensive approach would provide a clearer picture of the factors influencing an individual's anxiety and overall mental health.

We used Psychopy, a Python-based software package, to measure the selective attention and memory recognition ability in teenagers, as a proxy to approach the self-control capacity. Selective attention can be effectively tested using the Stroop task, which examines how individuals process and respond to conflicting information. In our 1st Psychopy task, participants are presented with color words such as "Blue," "Red," and "Green" in a color that may or may not match the word itself. In the incongruent condition, where the word's meaning and the ink color are mismatched (e.g., the word "Red" written in blue ink), participants typically exhibit longer reaction times due to the cognitive conflict between the word's meaning and its color. Conversely, in the congruent condition, where the word and ink color match (e.g., "Green" written in green ink), reaction times are shorter. The task involves 100 trials, with 50 trials for each condition, and includes five different colors, with each trial lasting 3-4 seconds.

In addition to selective attention, emotional memory recognition tasks provide insights into how emotional content affects memory. In our Psychopy experiments, words are categorized into emotional groups—Positive, Negative, and Neutral (Figure 1). For example, participants learn a list of 18 words, with six words from each emotional group randomly distributed. The task consists of five blocks of learning and testing, where participants first learn nine words from each block and are then tested with the full list. The hypothesis is that individuals with varying levels of anxiety will exhibit differing memory performance based on the emotional valence of the words. Specifically, it is expected that words from the Positive and Negative groups will be remembered differently compared to Neutral words, reflecting how anxiety influences emotional memory processing.

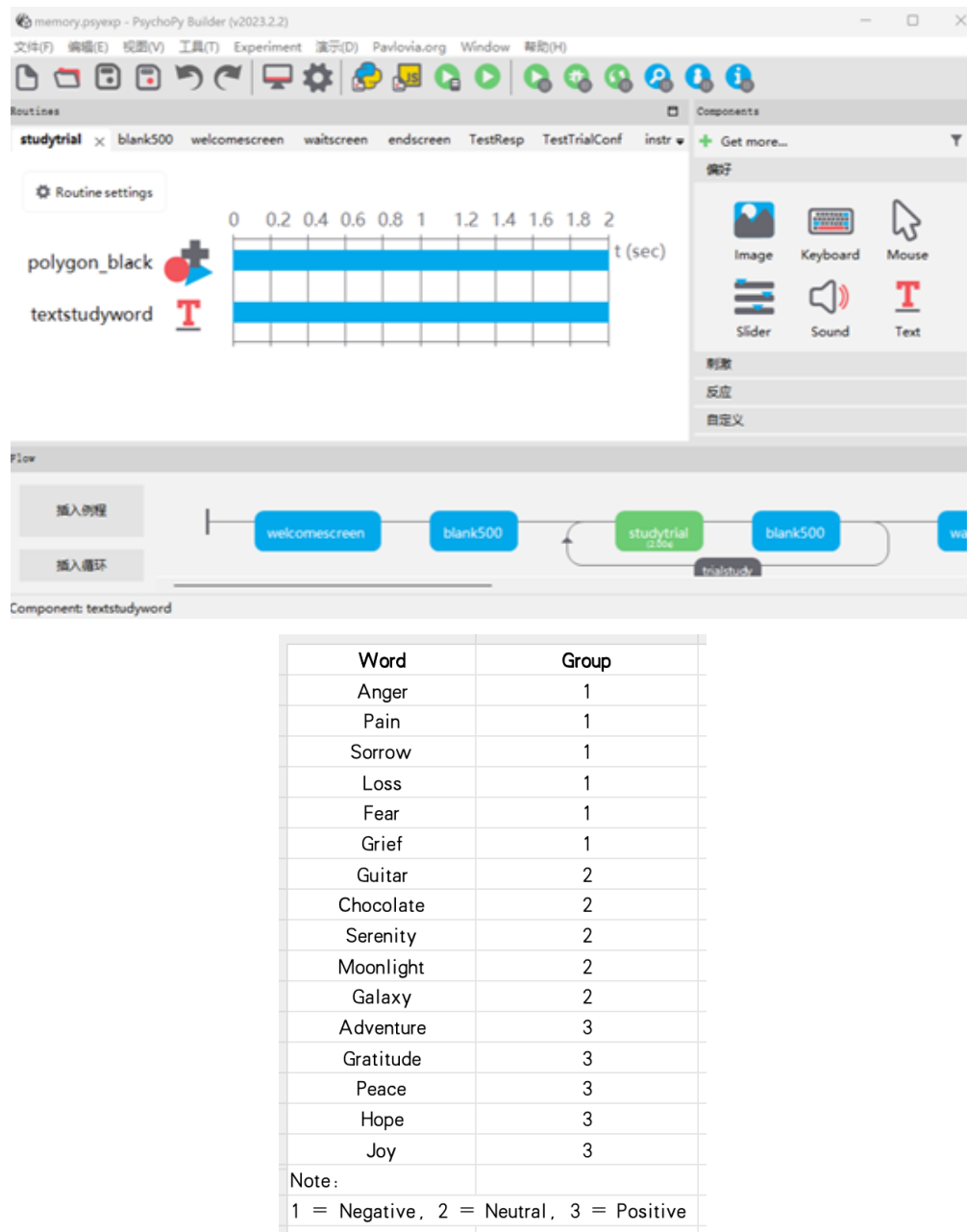


Figure 1. The layout of the emotion-based memory task in PsychoPy (above) and the three word categories in the Memory task (below).

5. Results

5.1. Experiment 1: A survey to quantify anxiety in adolescence

Our questionnaire reveals that teenagers with higher emotional management tend to have a closer relationship with their parents, and thus have better school life and family life. Which is consistent with the former assumption: self-control is related to anxiety by the executive functions. People who lack self-control may have problems communicating with their parents, and have anxiety problems due to bad communication and peer relationships.

The questionnaire also shows that adolescents with lower school life status have higher anxiety levels while having a better family life level does not mean lower anxiety levels. The anxiety level in adolescents is quite common. Figure 2 shows that most participants have uncertain prospects and don't hold high hopes for the future; those who have high hopes for the future make up a very small proportion (less than 10%).

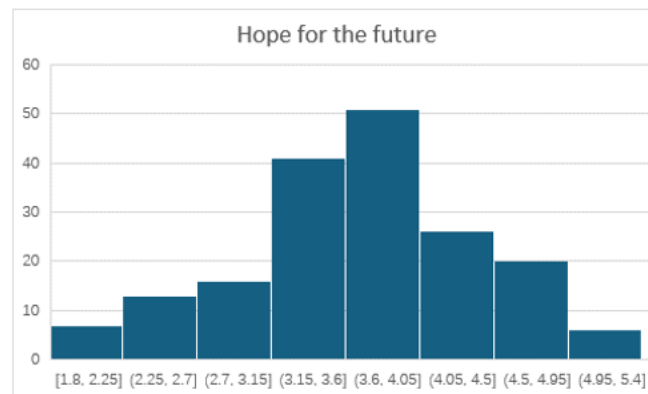


Figure 2. Hope for the future.

Notes: Proportion of only children: $136/180 = 0.75555$, meaning about three-quarters of the people are only children. 87% of people live with their parents. This graph reveals the amount of hope the participants have. The larger the number, the greater the hope.

In our study, a lower anxiety-positivity score indicates a higher level of anxiety. As shown in Table 1 and Figure 3, adolescents with higher levels of anxiety tend to display more negative emotions in their evaluations of school life. Additionally, the relationship between parents within the family can also affect their emotions. Adolescents with higher anxiety levels generally score lower on family relationships compared to those with higher positivity scores. However, no significant difference was observed in the anxiety-positivity scores regarding educational factors.

Table 1. Mean values of school life, education, and family relationships across different anxiety score ranges.

Anxiety-Positivity Score Range	School Life Moan	Education Moan	Familly Relationship with parents Moan
5-10	29.50	4.00	5.57
11-15	27.38	3.53	5.58
16-20	20.51	3.60	5.54
21-25	15.85	3.75	5.45

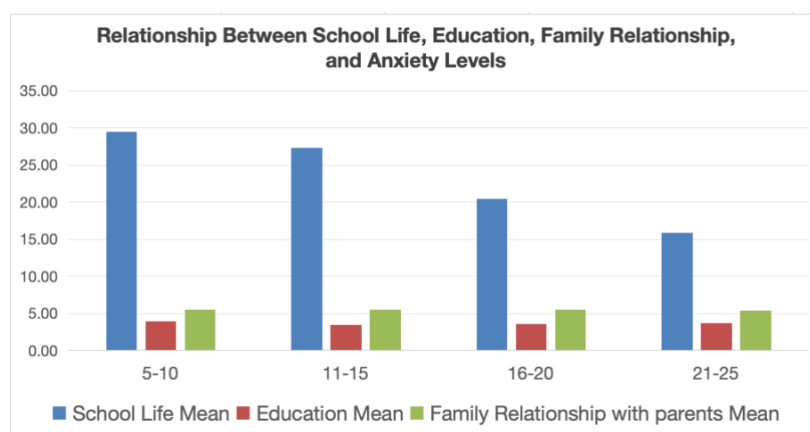


Figure 3. Relationship between school life, education, family relationships, and anxiety levels.

5.2. Experiment 2: Stroop task to measure selective attention

We first quantified the correctness rate of the subjects in the Stroop task. Among all 15 subjects (mean age = 15.87, male: female = 3:2), we reported that subjects have reached a high level of accuracy (mean = 95.8%) in their performance. After removing the very few error trials, we then quantified the reaction time of each subject in two conditions, namely, the congruent condition and the incongruent condition. We have found that it takes subjects longer reaction time in congruent conditions than incongruent ones.



Figure 4. Reaction time of all subjects in the stroop task.

Table 2. Reaction time of individuals in congruent condition vs. incongruent condition in the Stroop task.

Reaction time (sec)	Congruent	Incongruent
Subject 1	0.954	1.046
Subject 2	0.725	1.275
Subject 3	0.823	1.177
Subject 4	0.923	1.077
Subject 5	1.027	0.913
Subject 6	0.823	1.177
Subject 7	1.002	0.998
Subject 8	1.232	0.878
Subject 9	0.923	1.077
Subject 10	0.975	1.025
Subject 11	1.024	0.086
Subject 12	1.097	0.903
Subject 13	1.062	0.938
Subject 14	1.098	0.902
Subject 15	1.120	0.880

5.3. Experiment 3: Emotion semantic memory recognition task

We have performed the emotion semantic memory task with 15 subjects. We have quantified the memory recognition performances for three types/categories of words of different emotions – negative, neutral, and positive ones. These words were presented to the subjects in a randomized order in five blocks. We have collected the performance in each block.

Importantly, we found that neural words have a better correction rate than positive and negative words (See Figure 4).

Tables 3 and 4 list the specific performance of each subject in the experiments.

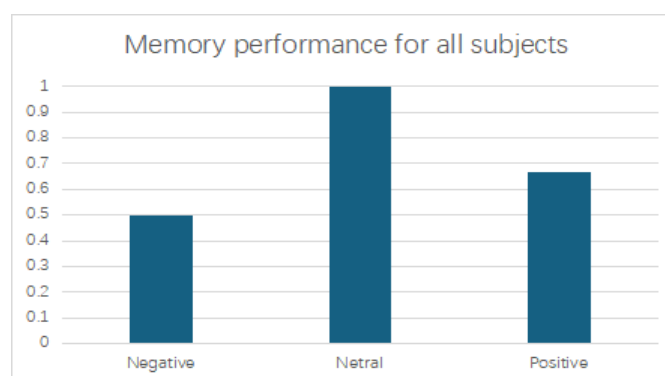


Figure 5. Memory performance for all subjects.

We found that Block 3 generally has the lowest correction rate. Blocks 2 and 4 have the second and blocks 1 and 5 have the most correction rate (see Figure 5).

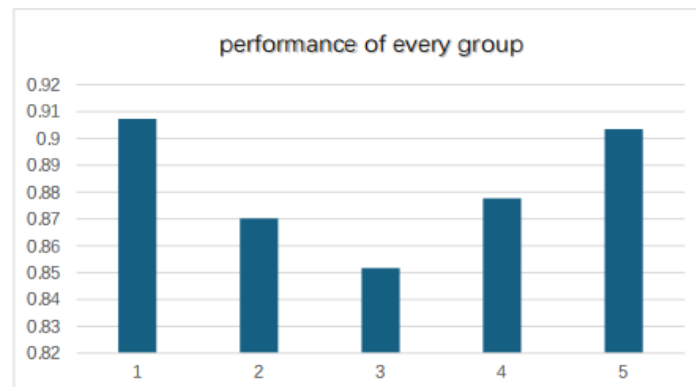


Figure 6. Memory performance of each block.

Table 3. Correctness rate of all subjects across blocks

Correctness rate	Block 1	Block 2	Block 3	Block 4	Block 5
Subject 1	0.833	0.833	0.833	0.889	0.944
Subject 2	0.944	0.944	0.833	0.889	0.778
Subject 3	0.667	0.722	0.611	0.722	0.833
Subject 4	0.833	0.778	0.944	0.722	0.944
Subject 5	0.889	0.944	0.889	0.944	0.944
Subject 6	1	0.889	0.889	0.944	0.833
Subject 7	1	1	0.944	1	1
Subject 8	0.944	0.889	0.944	0.833	0.944
Subject 9	0.833	0.778	0.667	0.778	0.833
Subject 10	0.889	0.833	0.833	1	0.944
Subject 11	0.944	0.944	0.944	1	0.889
Subject 12	0.944	0.944	0.889	0.944	0.944
Subject 13	1	0.944	0.722	0.889	0.889
Subject 14	0.889	0.889	0.944	0.778	0.944
Subject 15	1	0.722	0.889	0.833	0.889

Table 4. Correctness rate of three categories of words for each subject

	Correctness rate	Negative words	Neutral words	Positive words
Subject 1	Block 1	0.667	1	0.833
	Block 2	0.833	0.833	0.833
	Block 3	1	0.667	0.833
	Block 4	0.833	0.833	1
	Block 5	1	0.833	1
Subject 2	Block 1	1	0.833	1
	Block 2	1	1	0.833
	Block 3	0.5	0.833	1
	Block 4	1	0.833	0.833
	Block 5	0.833	0.667	0.833
Subject 3	Block 1	0.667	0.833	0.5
	Block 2	0.833	0.833	0.5
	Block 3	0.5	0.667	0.667
	Block 4	0.667	0.833	0.667
	Block 5	0.833	0.833	0.833
Subject 4	Block 1	0.833	1	0.667
	Block 2	0.833	1	0.5
	Block 3	0.833	1	1
	Block 4	1	0.833	0.333

	Block 5	1	0.833	1
Subject 5	Block 1	1	0.833	0.833
	Block 2	0.833	1	1
	Block 3	1	0.667	1
	Block 4	1	0.833	1
	Block 5	0.833	1	1
Subject 6	Block 1	1	1	1
	Block 2	1	1	0.667
	Block 3	0.667	1	1
	Block 4	0.833	1	1
	Block 5	0.833	0.833	0.833
Subject 7	Block 1	1	1	1
	Block 2	1	1	1
	Block 3	0.833	1	1
	Block 4	1	1	1
	Block 5	1	1	1
Subject 8	Block 1	1	1	0.833
	Block 2	0.833	1	0.833
	Block 3	1	0.833	1
	Block 4	0.833	1	0.667
	Block 5	0.833	1	1
Subject 9	Block 1	1	0.833	0.667
	Block 2	0.833	0.833	0.667
	Block 3	0.667	0.667	0.667
	Block 4	0.667	0.833	0.833
	Block 5	0.5	1	1
Subject 10	Block 1	1	0.667	1
	Block 2	0.833	1	0.667
	Block 3	0.667	1	0.833
	Block 4	1	1	1
	Block 5	0.833	1	1
Subject 11	Block 1	1	1	0.833
	Block 2	1	1	0.833
	Block 3	0.833	1	1
	Block 4	1	1	1
	Block 5	1	0.833	0.833
Subject 12	Block 1	0.833	1	1
	Block 2	0.833	1	1
	Block 3	0.833	0.833	1
	Block 4	1	1	0.833
	Block 5	1	1	0.833
Subject 13	Block 1	1	1	1
	Block 2	1	0.833	1
	Block 3	0.5	1	0.667
	Block 4	0.667	1	1
	Block 5	0.833	1	0.833
Subject 14	Block 1	0.833	0.833	1
	Block 2	1	0.833	0.833
	Block 3	0.833	1	1
	Block 4	0.833	1	0.5
	Block 5	0.833	1	1
Subject 15	Block 1	1	1	1
	Block 2	0.5	1	0.667
	Block 3	1	1	0.667
	Block 4	0.667	1	0.833
	Block 5	1	0.667	1

Table 4 reveals that individuals show different levels of memory performance for words of emotion vs. nonemotion categories: they remember positive and negative words more than neutral words. This suggests that emotional information may interact with memory cognition.

6. Discussions & Conclusions

6.1. The summary of main results

In our questionnaire, it effectively depicted the anxiety level in teenagers by using the typical characteristics of anxiety people. Anxiety is often linked to the relationship between students and their school life, so it would be more reasonable to reduce competitive aspects and increase opportunities for group work in students' school experiences. The relationship between students and their families, as well as their hopes for the future, is also correlated with anxiety levels. Students who have closer family relationships and are more likely to receive support and help from their parents tend to show lower levels of anxiety. Moreover, students who remain optimistic about their future and are committed to taking concrete actions toward their goals are less prone to experiencing anxiety.

The Stroop effect is effectively established in the Stroop test. When the participants face words that have colors mismatched with their meanings, the participants will usually spend a longer time doing this process, indicating the use of selective attention to resolve interference encountered in the incongruent condition. Selective attention is a type of executive function, which could be related to anxiety. Therefore, we speculate that the vulnerability towards selective attention may cause anxiety and affect emotional control. The Stroop task could be used to quantify and train self-control abilities.

When the semantic words are related to emotion, either positive or negative ones, subjects showed a lower level of memory recognition performance of these stimuli, in comparison with words without any emotion processing. For neutral words, such a process does not happen, so people can memorize more neutral words than positive or negative words. This suggests that cognitive responses and memory functioning of subjects may be highly related and can be influenced by information that is related to emotion. Furthermore, Negative emotional processing may be detrimental to one's memory processing.

Memory performance was found to be intricately linked with self-control. Enhanced memory capabilities, particularly in terms of working memory, seem to contribute to greater self-regulation. This suggests that improving memory might indeed lead to better self-control by enabling individuals to recall and apply coping strategies more effectively. Consequently, there is a potential for developing interventions that enhance memory to indirectly boost self-control and emotional management.

6.2. Limitations and Areas for Improvement

The current experiments have several limitations. The questionnaire, while detailed, may not capture all dimensions of anxiety, potentially missing subtle aspects of emotional experiences. Additionally, the Stroop task, though effective, may not fully represent real-world scenarios of cognitive interference. Memory performance metrics could also be broadened to include more diverse tasks to provide a fuller picture of memory's role in self-control. Future research could benefit from incorporating a wider range of anxiety measures and using more varied cognitive tasks to enhance the robustness and applicability of the findings.

6.3. Readdressing the Problem and Innovation

This study highlights the potential of using cognitive tasks focusing on self-control as interventions for adolescent anxiety. By integrating cognitive tasks like the Stroop test and memory exercises into therapeutic approaches, there is an opportunity to target underlying cognitive processes that contribute to anxiety. Such innovative interventions could enhance cognitive functions and emotional

regulation, offering a promising avenue for reducing anxiety and improving overall mental health in adolescents.

Addressing the problem of anxiety and related emotional issues involves focusing on prevention, intervention, and treatment strategies, with a particular emphasis on the role of self-control mechanisms and executive functions. Executive functions encompass a range of cognitive processes essential for goal-directed behavior, including self-control, which involves direct inhibition and interference control. These functions are critical in adolescence, a developmental period marked by significant cognitive and emotional changes. Self-control, a key component of executive functions, enables individuals to regulate their thoughts, emotions, and behaviors, which is crucial for managing anxiety. Selective attention, another aspect of executive function, plays a significant role in enhancing memory performance. Training aimed at improving selective attention can lead to noticeable improvements in memory performance before and after such interventions. The relationship between emotional issues and executive functions is evident in research showing that individuals with anxiety disorders often exhibit impaired self-control abilities. For instance, these individuals may struggle with inhibition and managing competing stimuli, leading to heightened anxiety and emotional distress. Thus, understanding and enhancing executive functions, particularly self-control, is vital for developing effective prevention, intervention, and treatment strategies to address anxiety and improve overall emotional well-being.

For future research, it would be an interesting direction to test whether teenagers who suffer from emotional issues show any difference in the neural activity in the prefrontal area, the amygdala, and the limbic system in general. Therefore, we would be able to know potential biomarkers to correlate emotional distress and anxiety with brain activity. In addition, one could also conduct the emotional memory recognition task together with fMRI scanning or EEG recordings, so that we may be able to identify potential brain activity changes in the limbic system while subjects memorize words of different emotional groups (i.e., negative, positive, and neutral).

6.4. Scientific significance

From the questionnaire, we can identify several stressors of anxiety and infer the factors contributing to decreased self-control (emotion management issues). These factors might be improved through cognitive training related to self-control functions. The psychophysical tests offers a potential intervention mechanism (through improvement in attention/memory), with these cognitive abilities serving as behavioral indicators of self-control.

In conclusion, in the current project, we have addressed the problem of anxiety and related emotional issues involves focusing on the factors and their potential correlations with cognitive functions. We used selective attention and memory capacity as proxies for quantifying the self-control abilities, with an aim to highlight the role of self-control and executive functions in emotion regulation and intervention in anxiety.

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