Role of Anxiety in Emotional Priming on Dual Mechanism of Control

A Thesis submitted for the partial fulfillment of the requirements for the degree of

MASTER OF ARTS IN PSYCHOLOGY

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

THAPAR SCHOOL OF
LIBERAL ARTS & SCIENCES
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CERTIFICATE

This is certify that the thesis titled **Role of Anxiety in Emotional Priming on Dual Mechanism of Control** is being submitted in partial fulfillment of requirements for the award of the degree of Master of Arts in Clinical Psychology, submitted in the Thapar School of Liberal Arts and Sciences, Thapar Institute of Engineering and Technology, Patiala. This is a bonafide work carried out under the supervision of Dr. Richa Nigam, Professor at Thapar School of Liberal Arts and Sciences, Thapar Institute of Engineering and Technology, Patiala and that no part of this thesis has been submitted for the award of any other degree.

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This is to certify that the above statement made by the student concerned is correct and true to the best of my knowledge.

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CANDIDATE’S DECLARATION

I hereby declare that the work presented in this thesis entitled, “Role of Anxiety in Emotional Priming on Dual Mechanism of Control” in partial fulfillment of the requirement for the award of Degree of Master of Arts in Psychology, Thapar School of Liberal Arts and Sciences, Thapar Institute of Engineering and Technology, Patiala, is an authentic record of my work carried out under the supervision and guidance of Dr. Richa Nigam, Professor, Thapar School of Liberal Arts and Sciences, Thapar Institute of Engineering and Technology, Patiala and refers other researcher’s work which are duly listed in the reference section. The matter embodied in this thesis has not formed the basis for the award of any other degree of this or any other university.

Date: June 2025

Place: Patiala

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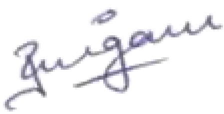

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ACKNOWLEDGEMENT

A major project is never the work of anyone alone. The contributions of many different people in different ways made this possible. A statement of thanks is evident to inculcate my deep sense of gratitude and obligations to all those who helped me in the work of my thesis. It has been a great honour and privilege to undertake my project in the Department of Psychology at Thapar Institute of Engineering and Technology, Patiala.

First and foremost, I am extremely thankful to my research supervisor, Dr. Richa Nigam (Professor of the Thapar School of Liberal Arts and Sciences), for her valuable supervision and consistent encouragement throughout the research work. She always made it a point to be available to clarify my doubts despite her busy schedule, and I consider it a great opportunity to do my research program under their guidance and learned the techniques of research expertise.

I would also like to thank the participants of this study for taking their time and effort to fill out the questionnaire and to perform the experiment as honestly as they did, as they made the research possible. Finally, I would like to thank my family for their unwavering support throughout my college education and for always providing great encouragement.

ABSTRACT

Cognitive control enables the modulation of action and thought in response to internal objectives, promoting adaptive functioning in complex situations. The Dual Mechanisms of Control (DMC) theory argues that cognitive control is divided into proactive (goal-directed) and reactive (stimulus-driven) modes that help to flexibly mold their actions depending on the requirements of the given task. The current research examines the interaction between the influence of emotional priming (anger, sadness, happiness, and neutral states) and trait anxiety (high and low) on dual mechanisms of control through a spatial Stroop paradigm. Using the State-Trait Anxiety Inventory (STAI) to differentiate anxiety levels and examine the interference effects with varying proportions of congruence to address dual mechanisms of control under varying emotional conditions, this research seeks intervention to address important gaps in cognitive-affective control literature.

Keywords: Dual Mechanisms of Control; Emotional Priming; Trait Anxiety; Spatial Stroop Task; Conflict Adaptation

CONTENTS

Chapter 1. INTRODUCTION

1.1 Cognitive control

Cognitive control enables us to control thoughts, feelings, and behaviors in response to shifting goals and pressures from the outside world (Nigam & Kar, 2021). Under cognitive control, scientists have made a difference between proactive control, which enables us to prepare beforehand, and reactive control, which helps us to solve conflicts at the moment (Braver, 2012). To comprehend how these two types of control function, particularly in attentional control tasks such as the Stroop task, is fundamental to assess cognitive controls, attentional regulation, and reaction processing time.

Cognitive control processes enable individuals to react to several shifting circumstances and change their behaviors based on them. This suggests that an individual has to oversee automatic reactions with incompatible interfering stimuli, along with choose working memory objectives. Effective cognitive control is necessary for problem-solving, decision-making, and goal-directed action, and if such cognitive control malfunctions, then it would lead to psychological diseases like ADHD, anxiety, and schizophrenia.

The Stroop task is the well-known test used to study cognitive control. The subjects are asked to name the color of a word while ignoring the word's meaning in the standard version. The word's meaning either happens to agree (congruent) with the color (for example, 'red' in red) or disagree (incongruent, for instance, 'red' in the color blue). The task induces conflict in thought, thus offering a good way to monitor people using different strategies in the management of conflicting information (MacLeod, 1991).

1.2 Dual Mechanism of Cognitive Control: Proactive and Reactive Controls

The Dual Mechanisms of Control (DMC) account suggests that cognitive control is mediated by two qualitatively distinct strategies. The first strategy is to prepare in advance by maintaining task goals actively in mind so as to control behavior, and the second is to respond only when difficulties or conflicts occur, permitting the individual to react to demands as they arise. These tactics vary in when and how control is exercised: one prioritizes anticipatory, sustained regulation, while the other prioritizes situational, on-the-fly modulations. The DMC approach points out that people are able to switch between these modes based on task context, environmental cues, or personality tendencies, and that these modes might function separately rather than as varieties of one process (Braver, 2012). Proactive control is characterized by sustained activation of goal-relevant information before the occurrence of a cognitive challenge (Braver, 2012). This mode of control helps individuals to plan ahead of themselves and enhance their performance in tasks that require selective attention and reaction control. For instance, one who employs proactive control strategy in Stroop tasks is well prepared for the task and suppresses conflicting cues of information.

In opposition to that, reactive control only comes into action when it has detected conflict or challenge and serves as an instantaneous, correcting mechanism to interfere with (Braver, 2012). Reactive control is more transient in nature; because it is momentary, it processes conflicts once they occur by identifying conflict and invoking balanced responses to correct it (Visalli, 2023). Reactive control is largely useful in settings or conditions that are not predictable. For instance, subjects with a reactive control strategy during the Stroop task may have higher interference effects but display robust corrective changes following the occurrence of conflicting stimuli.

Previous work has pointed out that individuals with greater working memory capacity will tend to utilize proactive control more, taking advantage of goal persistence (Yang, 2018). In contrast, those with lesser working memory capacity will have to use more reactive control, accommodating conflicts in the moment. This means that proactive control uses cognitive resources to maintain attention, whereas reactive control acts back only when get distracted or lose focus. In the stroop task, how an individual uses these controls depending on how mental effort, motivation, and mood an individual is putting in.

Different individuals use proactive and reactive control differently in the Stroop task, depending on different factors like how much effort they put in, their motivation levels, and their mood. For instance, an individual with strong working memory will use proactive control rather than reactive control as they can easily differentiate between the important goals in mind (Kane & Engle, 2003). Anxiety can make it hard for an individual to use proactive control, and individuals are more likely to use reactive control because they are easily distracted and are less likely to concentrate on their goals (Eysenck et al., 2007). These findings show how flexible cognitive control is and how crucial it is to make techniques flexible so that they can work well in different situations.

Understanding about proactive and reactive control in the Stroop task informs us about general thinking abilities, such as decision-making and self-control. This information is beneficial when developing programs to enhance focus and control in patients with disorders like ADHD or anxiety. By teaching individuals to employ more proactive control, we can assist them in concentrating better, being less impulsive, and being more flexible thinkers. Another handy instrument is the Spatial Stroop Task, which would check how we respond to conflicting information. Supposing the word "LEFT" is at the right-hand side of the screen, you would be prompted to react to what the word indicates, rather than where it is. When the meaning of the word and its location do not align, individuals are slower or make errors. This indicates how automatic spatial thinking is and how much brain control is required to answer correctly.

The spatial Stroop task is crucial to understanding how proactive and reactive controls work. In proactive control, an individual thinks ahead and tries not to get confused, and mainly focuses on the main parts of the task, whereas in reactive control, an individual doesn't plan anything ahead, just deals with the confusion when it arrives.

In addition, individuals are increasingly curious about how emotion and anxiety influence spatial Stroop performance. Research indicates that increased anxiety can make it more difficult for individuals to manage their behavior prior to acting, so that they are more susceptible to the influence of conflicting spatial information. Alternatively, anxious individuals may exhibit greater responses when conflicts occur immediately. This is the same pattern that we observe in standard Stroop tasks, further arguing that emotion can play a role in how we regulate our thinking in spatial tasks.

1.3 Affect-Based Cognitive Control

Emotional and motivational states also contribute significantly to inhibiting the association between proactive and reactive controls (Nigam and Kar, 2021). Anxiety, for example, has been found to interfere with proactive control while promoting reactive control. This is because worry associated with anxiety uses up cognitive resources needed for sustained attentional preparation, causing individuals to resort to a reactive strategy (Yang, 2018). Preattentive attention is found to be engaged for tasks demanding emotional goals (Issacowitz et al., 2018). This hints at emotional goals benefitting proactive control abilities in old age.**Emotional priming** plays an important role in variating between proactive and reactive control, as it can influence attentional focus, reaction time, and cognitive flexibility. Whether positive or negative, emotional priming has been found to either enhance the cognitive controls or impair cognitive control, depending on the priming, which can be either good or disgusting, and how each individual regulates that emotion (Pessoa, 2009). When individuals are exposed to these emotional primings before any cognitive task, it influences different control strategies and alters the balance between proactive and reactive control.

Proactive control is susceptible to emotions because it relies on maintaining attention and tracking goals. Strong emotional reactions disrupt this attention. Research has confirmed that negative emotions, like fear and anxiety, harm proactive control. When an individual's anxiety levels are high, their brain or cognitive controls don't work as well, their working memory gets weakened, and they get distracted easily (Eysenck et al., 2007). But whereas when not feeling stressed or anxious, your cognitive functions work better and stay more stable, which helps to do tasks more effectively, even when distractions might happen and you're ready for them (Schmidt & Weissman, 2014).

Reactive control, on the other hand, helps to deal with problems as they arise. When we show emotionally charged stimuli, especially negative ones like angry or sad faces, it makes an individual more alert. This charges up one's alertness and boosts the brain to respond quickly and effectively to conflicts as they arise (Braem et al., 2017). For instance, studies have demonstrated that when individuals see negative emotional stimuli, they react faster on the Stroop task, but the effect is short-lived. This shows that strong emotions like anger can boost the reactive control, but they reduce our ability to rely on proactive control, which needs long-term focus and planning (Chiu & Egner, 2015). The varying influence of emotional priming on reactive and proactive control is significant in determining how emotions affect thinking in daily life.

1.4 Anxiety and Cognitive Control

Anxiety plays a crucial role in how we use proactive and reactive control. As it affects our abilities to focus and stop an individual from reacting too quickly. Prior studies show that highly anxious people respond quickly and are unable to stay focused, which has a greater negative effect on proactive control. As a result, an individual who has high anxiety will mostly rely on reactive control, which will lead to responding quickly without even planning (Eysenck et al., 2007). This adaptation can lead to higher cognitive instability due to the fact that anxious people may have difficulty sustaining their goals over a long period and instead react to things in a more immediate, stimulus-driven way (Yang et al., 2018).

Extremely anxious people, therefore, might use reactive control more because they are highly sensitive towards emotional stimuli. This heightened sensitivity towards strong emotions make them reactive quickly but might make it harder for them to plan ahead and stay focused over time (Yang et al., 2018). This indicates that emotional priming can decrease thinking impairments based on personality and situation.

Negative emotional priming appears to make individuals more reactive in how they manage their behavior. Research has indicated that being exposed to negative emotions makes individuals more alert and less adaptable in their thought, making them more reliant on reactive control tactics (Visalli et al., 2023). In the Spatial Stroop task, this is reflected in longer response times and greater difficulty with distraction, as individuals respond to issues rather than anticipating them in advance.

Also, whether or not control of thinking in the Spatial Stroop task is affected by emotional priming is susceptible to variations in anxiety. Individuals who are high in anxiety will be prone to compromised proactive control following negative emotional priming since their minds are preoccupied with concern (Braver, 2012). This results in more reliance on control that is reactive, which can be detrimental to performance in tasks requiring focused attention.

Low-anxiety persons generally maintain control even when confronted by negative affect. They can handle emotional distraction and stay focused on the task, and this enables them to work better on the Spatial Stroop task. This indicates that the regulation of emotion is extremely critical as regards the influence of emotional cues on processes of control and thought. Despite all these difficulties, anxiety is not always bad for cognitive control. According to some studies, moderate levels of anxiety can help an individual to stay alert and respond quickly when challenging tasks come up, as it improves reactive control (Robinson et al., 2013). This heightened alertness can be helpful in challenging tasks where quick actions are needed to handle sudden changes. However, too much anxiety and relying too much on reactive control can lead to bigger problems, such as being unable to shift thinking and making more mistakes when doing something complex.

The relationship between emotional priming, proactive and reactive control, and the Spatial Stroop task helps us understand how an individual thinks and adapts to challenging situations. By studying how different emotions affect our attention, further studies can research how an individual stays focused and handles conflict in their thinking.

1.5 Cognitive controls interplay with emotional priming and anxiety

In the previous studies, the researchers provided insights into how proactive and reactive controls operate within the Stroop task. This explored the difference between these control strategies, showing how individuals switch between proactive and reactive controls according to the tasks assigned to them (Braver, 2016). Additionally, some studies show how emotions can affect these controls and found that emotional stimuli can change how an individual manages their attention. This can further shift the balance between using these strategies (Visalli, 2023).

An important area of investigation includes the role of anxiety in cognitive control. That state anxiety impairs proactive control while enhancing reactive control (Yang, 2016), suggesting that anxious people rely more on the reactive control, which is quicker and does automatic reactions instead of staying focused over time. These findings show that the emotional stimuli or emotions truly and strongly influence our cognitive thinking and behaviour. This could be important to understand and improve performance in everyday life.

Proactive control helps us think ahead and relies on keeping important information active in the working memory. This occurs well when an individual can predict what's coming next and get ready ahead of time, which blocks out distractions and sustains attention to the task (Braver, 2016). This control strategy is particularly advantageous in structured tasks, where cues signal the need for sustained attention and early response preparation.

In contrast, reactive control kicks in later, which helps us deal with conflicts as they arise. Instead of keeping key information always in mind, reactive control is employed only when required. This allows individuals to respond quickly to sudden changes in the environment (Braver, Gray, & Burgess, 2007). Reactive control can be helpful when things happen differently than expected, but as it is all about quick adaptation, it makes you distracted which increases your response speed.

The balance between proactive and reactive control is determined by several factors, such as individual differences, task demands, and emotional states. For instance, it shows that younger people tend to use more proactive control rather than reactive control. In contrast, older adults rely on reactive control as their working memory is not as strong as that of younger individuals (Braver et al., 2009). In the same way, emotional states like anxiety can interfere with proactive control by making it harder to focus and which leads to more use of reactive controls (Eysenck et al., 2007).

1.6 Background and context

Cognitive control is the capacity to regulate actions, attention, and responses in terms of our own goals and the events in the environment (Miller & Cohen, 2001). The most important theoretical contribution to cognitive control is the Dual Mechanisms of Control (DMC) theory, which was described by Braver (2012). The theory postulates two forms of control: proactive and reactive. Proactive control enables us to plan ahead and retrieve pertinent information, which directs our attention and decision-making, while reactive control is a standby in the event of spontaneous conflict or unexpected occurrence.

The manner in which individuals manage their thoughts isn't constant, it varies depending on external influences and the manner in which they feel. Feelings are quite influential in this regard. They contribute significantly to the manner in which an individual thinks and reaches decisions. For instance, positive emotions can cause an individual to be more flexible in their thinking and observe more (Fredrickson, 2001), whereas negative emotions such as fear or sorrow can constrict their attention and enhance concentration (van Steenbergen et al., 2010). These emotional impacts vary depending on context and may assist or hinder the performance of an individual in controlling tasks, depending on the emotion type and task type (Pessoa, 2009).

Emotional priming is an established cognitive psychology paradigm where emotionally arousing stimuli (e.g., facial expressions) are presented to participants prior to a cognitive task. Emotional priming can assist or hinder performance based on the emotional stimuli and task. For example, sad and angry primes have been shown to enhance interference on Stroop tasks particularly when mental control is low (Kalanthroff et al., 2015; Hart et al., 2010), whereas happy or neutral primes tend to produce less interference and aid goal-directed behaviour under more challenging conditions.

Anxiety, as a temporary state, strongly affects how we use our ability to think. According to the Attentional Control Theory (ACT) of Eysenck et al. (2007), anxiety doesn't reduce the extent to which we can think but makes it harder to focus on the task an individual is trying to do. This results in anxiety pulling the attention away from the task given towards what's happening around. Supporting this hypothesis, Yang et al. (2018) demonstrated that when anxiety was induced in a laboratory using a threat-of-shock procedure, individuals performed less well on tasks that involved planning (AX-CPT) but better on tasks that involved rapid reaction (Stroop)—demonstrating a shift in how they controlled.

Despite these results, there remains a large research gap regarding the interaction between anxiety and emotional prime on the two control modes. Anxiety and emotional priming have been separately found to influence control mode, but there are not many studies on how the two interact in the same experiment. The spatial Stroop task is an excellent vehicle for such a study because it allows researchers to measure both how conflicts are resolved (with congruent/incongruent stimuli) and where attention is directed, and it has emotional cues through facial image priming (Visalli et al., 2023).

Therefore, in summary The Dual Mechanisms of Control (DMC) theory (Braver, 2012) proposes that there are two types of cognitive control operating in different modes: proactive control wherein contextual and affective sources also impact the control mode preferred (Braver, 2012; Gonthier et al., 2016). In addition to this, emotional priming is a well-documented method for manipulating affective context for cognitive control. Research has shown that exposure to emotionally charged stimuli—such as sad faces, can influence attentional processes and cognitive control by increasing arousal and prioritizing salient information (Kalanthroff et al., 2015; Hart et al., 2010). Sadness, for example, has been linked with increased cognitive interference and reduced goal maintenance (Gable & Harmon-Jones, 2010), while anger may heighten conflict sensitivity, potentially facilitating reactive control (van Steenbergen et al., 2010). Neutral expressions, on the other hand, have been associated with more sustained, proactive attentional strategies in tasks requiring inhibitory control (Fredrickson, 2001; Visalli et al., 2023). However, despite the evidence that emotional primes modulate cognitive control, most studies have focused on a narrow range of emotions or have not systematically compared all four basic affective valences in the same paradigm. A related research by Yang et al. (2018) further provided experimental evidence that induced state anxiety also impairs proactive control (using an AX-CPT task) but improved performance in a Stroop task, which primarily relies on reactive control. Similarly, individuals with high trait anxiety show reduced recruitment of prefrontal regions involved in goal maintenance and increased distraction in the presence of emotionally salient information (Bishop, 2009). Despite these insights, very few studies have examined the joint influence of emotional priming and anxiety on the recruitment of dual control mechanisms. Most notably, Visalli et al. (2023) incorporated sad emotional priming in a Stroop-like task and found that emotional interference could be reduced by proactive or reactive control depending on the control demands. However, their study did not address how different emotional expressions (such as anger or happiness) interact with individual anxiety levels in modulating control strategy.

Chapter 2. Review Of Literature

Growth in research indicates that cognitive control is dynamically modulated by affective states like emotions and disposition variables like anxiety (Inzlicht, Bartholow, & Hirsh, 2015). Such affective modulation can modulate both the efficacy and the mechanism of control utilized by individuals on cognitive tasks.

The Dual Mechanisms of Control (DMC) model by Braver (2012) offers a useful theoretical perspective for examining these interactions. Cognitive control, in DMC's view, is performed in two different modes: proactive control, which is goal-driven and anticipatory, and reactive control, which is conflict-triggered and stimulus-driven. Although much work has been conducted to explore cognitive control and the neural mechanisms supporting it, relatively less effort has been directed to how anxiety and emotional priming interplay modulate these double mechanisms of control, especially within experimental paradigms like the spatial Stroop task.

2.1 Cognitive Control via The Stroop Task: The Spatial Stroop Variants

The Stroop task remains the gold standard for assessing cognitive control and interference management. In its classical form, individuals are required to name the ink color of words that may be congruent or incongruent with the word's meaning (MacLeod, 1991). The increased reaction time and error rates for incongruent trials, known as the Stroop effect, reflect cognitive control demands. The Stroop task is a classic tool for studying control modes. Gonthier et al. (2016), in their study with 93 participants, used it to show that proactive and reactive control were found to be independent mechanisms as observed in the same participants under different conditions. Neuroimaging studies have shown that the ACC is activated during conflict monitoring, while the DLPFC is involved in implementing control to resolve conflict (Banich et al., 2000). These findings form the neural basis for dual mechanisms of control within the Stroop paradigm.

The spatial Stroop task introduces spatial rather than semantic conflict. For example, participants may be required to respond to the direction an arrow points, even when its spatial location is incongruent (e.g., a right-pointing arrow on the left side of the screen). Lu and Proctor (1995) established the spatial Stroop effect, demonstrating robust interference patterns akin to those in the classic Stroop. Stoet (2010) further validated the spatial Stroop task as a sensitive measure of attentional and control shifts. Despite these advances, few studies have examined how anxiety interacts with emotional priming in modulating spatial Stroop performance, thereby, representing a clear research gap.

2.2 Cognitive Control and Affect based influences

Egner (2007) showed that cognitive control is dynamically tuned according to task requirements, e.g., conflict rate. Gonthier et al. (2016) empirically dissociated proactive and reactive control in the Stroop task, showing that individuals flexibly shift between these modes based on task demands and individual differences. Chiew and Braver (2014) further demonstrated that motivational and affective factors can bias the engagement of one control mode over the other.

There is emerging evidence that emotional state and personality systematically influence cognitive control processes (Pessoa, 2009; Inzlicht et al., 2015). For example, Chiew and Braver (2011) reported that positive affect and reward enhance cognitive control but in different ways positive affect boosts flexibility, while reward improves goal focus.

Eysenck et al's. (2007), Attentional Control Theory (ACT) posits that anxiety impairs attentional control by weakening goal-directed attention and enhancing stimulus-driven attention, especially toward threat. This reduces processing efficiency but not necessarily performance quality, due to compensatory effort.

Recent reviews by Braver et al. (2012) affirm the flexibility of control modes and call for more research into how affective and trait factors influence this flexibility. Pessoa (2009) argued that emotion and motivation dynamically shape executive functions, including control mechanisms. Yet, interactive effects involving emotional priming, anxiety, and control modes remain insufficiently explored.

2.3 Emotional Priming and Its Influence on Cognitive Control

Emotional priming refers to the exposure to affective stimuli that influence subsequent cognitive processing. This priming can be conscious (e.g., briefly presented emotional faces) or subliminal. Pessoa (2009) argued that emotion and motivation influence both what we perceive and how we control behavior. They can enhance or impair executive control depending on how they interact with brain systems like the anterior cingulate cortex, amygdala, and prefrontal cortex—a concept explained by the dual competition framework. Recent extensions by Visalli et al. (2023) incorporated emotional priming into spatial Stroop paradigms, finding that emotional stimuli significantly modulate interference control. In their study they applied emotional priming in a spatial Stroop task with 72 participants and observed that reaction time increased after emotional priming of sad stimuli only in congruent trials when cognitive control demands decreased.

Hart et al. (2010), with a sample of 36 adults, found that negative primes increased ACC activation and slowed responses during Stroop tasks, indicating heightened conflict monitoring demands triggered by emotional stimuli.

Interestingly, not all emotional priming effects are disruptive. Chiew and Braver (2011) found that positive affect can enhance cognitive control under certain task conditions.

This mixed pattern underscores the need to include both positive and negative primes, as in the current study, to capture the full spectrum of emotional influences.

2.4 Modulating effects of Anxiety over Cognitive Control

Anxiety has been consistently identified as a critical factor influencing cognitive control processes. According to Eysenck et al. (2007), Attentional Control Theory (ACT) posits that anxiety impairs attentional control by weakening goal-directed attention and enhancing stimulus-driven attention, especially toward threat. This reduces processing efficiency but not necessarily performance quality, due to compensatory effort.

Derakshan and Eysenck (2009) provided that anxiety mainly reduces processing efficiency, not performance quality, by impairing attentional control.

Similarly, Kalanthroff et al. (2016) this study found that high trait anxiety reduces proactive attentional control during a Stroop task when emotional (aversive) distractors are present. High-anxiety individuals showed more Stroop interference and reversed Stroop facilitation, indicating impaired control. Low-anxiety individuals were unaffected.

Yang et al. (2018) similarly reported that state anxiety impaired proactive preparation but promoted reactive control responses in their sample of 73 undergraduates, supporting an interaction between affective state and control mode selection.

Empirical support comes from studies using conflict tasks such as the Flanker and Stroop paradigms. Yang et al. (2018) demonstrated that state anxiety impairs proactive control while enhancing reactive adjustments. These findings converge to suggest that anxiety biases cognitive control systems toward more reactive strategies.

While substantial evidence links anxiety to impaired proactive control and heightened reliance on reactive mechanisms, several gaps persist. Most studies examine anxiety effects in isolation, without considering interaction with emotional priming. There is limited use of spatial Stroop paradigms to investigate anxiety-control dynamics. Positive emotional contexts have rarely been explored in relation to anxiety and control mechanisms. These gaps underscore the need for integrative studies combining emotional priming, anxiety stratification, and dual mechanisms of control measures, as proposed in the present research.

2.5 Converging Evidence from Recent Studies

Emerging research indicates that emotional priming effects are magnified in individuals with higher anxiety levels.

Saunders and Jentzsch (2014) reported that while general cognitive control mechanisms are intact, depression may specifically hinder the regulation of emotional information.

Further studies have extended these findings. Etkin et al. (2015) emphasized how different brain regions support automatic and deliberate emotion regulation, using a unified framework based on neuroimaging and reinforcement learning models.

Inzlicht et al. (2015) argued that cognitive control is fundamentally emotional. Goal conflicts trigger negative emotions, which in turn initiate and sustain control processes.

Chiew and Braver (2011) reported that positive affect and reward enhance cognitive control but in different ways positive affect boosts flexibility, while reward improves goal focus.

This mixed pattern highlights the need for further research examining valence-specific interactions between emotional priming, anxiety, and control modes

Overall, the literature review in this chapter highlights the dynamic interaction of emotional priming, anxiety, and cognitive control processes. Although the emotional priming and anxiety have been found to affect control modes separately, few studies have investigated their combined effect. Nevertheless, important gaps remain, especially regarding the contribution of positive emotions and the application of spatial stroop task paradigms in investigating such interactions. Additionally, developmental, cultural, and longitudional approaches are underemphasized in extant research. The current research therfore, addresses these gaps by investigating how different emotional primes and trait anxiety interact to influence proactive and reactive control modes, in a spatial stroop task.The current study aimed to investigate the influence of emotional priming on dual mechanisms of control and examined the impact of different anxiety levels on these cognitive processes. While DMC model and empirical studies of Gonthier et al. (2016), Visalli et al. (2023), and Yang et al. (2018) confirm both emotion and anxiety modulate modes of cognitive control, significant gaps exist. Spatial stroop paradigms have not yet been fully tapped in investigating the interaction. Additionally, few researchers have measured several emotional primes simultaneously (happy, angry, neutral, and sad) while grouping participants according to their anxiety levels. Filling these gaps will facilitate an understanding of how effective and dispositional variables contribute to proactive and reactive processes together.

Chapter 3. Research Gap, Objectives, Rationale And Hypotheses

3.1 Objective

The purpose of this study is to investigate how emotionally valenced stimuli—specifically facial expressions representing anger, sadness, happiness, and neutrality—influence the engagement of proactive and reactive cognitive control mechanisms during performance on a spatial Stroop task. A secondary but equally critical aim is to examine how individual differences in anxiety, as trait anxiety, moderate the relationship between emotional priming and control mode selection.

3.2 Research Gap

Despite the growing literature, several limitations persist in the study of Dual Mechanisms of Control in an affective context such as: a) positive emotional priming remains underexplored compared to negative emotions; b) most studies focus on verbal Stroop tasks, with limited research using spatial (or numerical) variants; c) few studies stratify participants based on trait anxiety, limiting insights into individual differences. The present study therefore, addresses these gaps by modulating DMC via variable proportion congruency in the presence of variable emotional primes of variable valences (anger, sadness, happiness, neutral) and examining their effects relative to anxiety levels of the participants using a spatial Stroop paradigm.

3.3 Hypotheses

H_1: Anxiety will influence the dual mechanisms of control. Better control for the low-anxious group will be observed than for the high-anxious group.

H_2: Emotional priming will interact with anxiety and influence dual mechanisms of control. High anxiety group, when primed with high-arousing emotions (such as Happy and Angry) will be facilitated on cognitive control in general in comparison to low-arousing emotions (Sad or Neutral).

Chapter 4. Methodology

4.1 Sample

G*Power 3.1 analysis (Faul et al. 2007) was used to determine the sample size. Based on previous literature (Nigam and Kar 2018; Visalli et al., 2023), the expected range of effect sizes was between ηp^2 =.20 and ηp^2 =.50 for the effect of age and conflict adaptation on measures of interest. To detect an effect size of ηp^2 =.50 with 0.95 power and alpha = .05 in the current study, the required sample size was estimated to be *N* = 70 participants. Informed consent was taken from all the participants before they participated in the study, and the task was carried out by the guidelines of the IRB committee. 90 participants (Mean age: 22.25 years; 45 females) volunteered to participate in the study. Out of which 45 participants had low trait anxiety and 45 participants had high trait anxiety.

4.2 Design

For the present study, a mixed factorial design was used. independent variables were anxiety (high versus low), emotions (happy, sad, angry, and neutral), proportion congruency (high LWPC, low LWPC, high ISPC, low ISPC, and equal blocks), and congruence (incongruent and congruent). Dependent variables were reaction times, error rates, and the Stroop effect.

4.3 Statistical Analysis

Reaction times (RTs) and accuracy (error rate %) were recorded. Reaction times were filtered by eliminating anticipatory responses and/or late responses. Outlier criteria involved removing trials beyond the range of ±3SD from the condition specific means. 5 males and 10 females were removed from the analysis as outliers based on their moderate anxiety levels. After excluding the outliers, only correct response trials were used for the analysis with RTs. The minimum range for adequate accuracy was 85% overall accuracy. Data of no participants was excluded from the analysis due to low accuracy of more than 50% errors during their task performance. Mean accuracy across participants was 96.84

Overall, two four-way ANOVAs were performed on reaction times (RTs) and Standard Errors (SE: Incongruent RTs- Congruent RTs) with JASP software using: 2(Anxiety: high, low) x 4(Emotions: happy, sad, neutral, anger) x 5(Proportion congruence: high LWPC, low LWPC, high ISPC, low ISPC, equal blocks) x 2(Congruence: congruent, incongruent). Planned comparison tests on aggregate RTs across groups for each emotion were conducted to compare their performance for each emotion.

4.4 Tools

1. State-Trait Anxiety Inventory (STAI; Speilberger, 1983):

The STAI is a well-established, commonly employed psychological test that quantifies two forms of anxiety: state anxiety (transitory emotional condition) and trait anxiety (overall tendency to be anxious). The test contains 40 self-report items—20 for state anxiety and 20 for trait anxiety—each rated on a 4-point Likert scale.

In the current research, the STAI scale was used to sort participants into high and low anxiety groups depending on their scores of trait anxiety. The sorting was important when examining the effect of different anxiety levels on cognitive control during the task.

2. Spatial Stroop Task for Emotional Priming:

This is a variation of the Stroop task using the standard Stroop methodology with affective facial expressions as priming stimuli. Participants received facial expressions (angry, happy, sad, neutral) as primes before receiving spatial word-location pairs (e.g., the arrow pointing towards upper right corner in the upper left corner).

Participants were asked to respond according to the direction where the arrow was pointing, rather than its position. Congruent and incongruent trials were employed to control for cognitive control demand.

The task was constructed to assess the interaction between emotional interference and cognitive control, specifically how emotional priming influences performance under different amounts of proactive and reactive control.

4.5 Procedure

The participants were informed about the study's purpose and provided with the necessary instructions. They were given a consent form to sign, indicating that they understood the study's purpose and that their participation was voluntary. Then the participants were seated in a quiet room where they performed the experiment without any disturbances. Participants were initially asked to undergo the State-Trait Anxiety Inventory (STAI) to determine the level (high or low) of trait anxiety. Participants were then divided into high anxiety or low anxiety groups based on their answers for further study. After the STAI, the participants completed a practice trial block of the Emotional Priming Spatial Stroop Task. In this block, they were given feedback following each trial, whether their response was correct or not. Participants had to reach a minimum of 75% accuracy in the practice block to be eligible for the main experiment, and this practice block consisted of 40 trials. Participants who passed on to the main task, and this involved three blocks lasting about 7 minutes each, within these three blocks, it further consisted of 2 blocks which were either highLWPC, lowLWPC, or equal blocks, and within each block was the ISPC condition. Each block was completed by a participant, after which a short break was given to lower fatigue and ensure consistency in performance. During the task, facial expressions of emotion (happy, sad, angry, neutral) were employed as the priming stimuli, and participants were told to make their responses according to the direction of the arrow where it was pointing ignoring its location. When the third block ends, the screen shows a thank you message, which shows the experiment has ended. Breaks were provided between each of the three blocks to prevent cognitive fatigue and maintain consistent performance levels throughout the task. The overall task duration was about 25 minutes.

Chapter 5. Results

For the data analysis, the mean and standard deviation were computed for all the variables. A 2 x 4 x 5 x 2 factorial ANOVA was also computed.

The mean and standard deviation were computed for each emotion, proportion congruence, congruency, and anxiety levels. The values are given in Table 1.

Table 1: Descriptive statistics.

Emotions	**Proportion Congruence**	**Congruency**	**Anxiety**	**N**	**Mean**	**SD**
Happy	HighLWPC	Cong	high	45	0.513	0.129
			low	45	0.445	0.080
		InCong	high	45	0.662	0.158
			low	45	0.560	0.125
	LowLWPC	Cong	high	45	0.517	0.127
			low	45	0.459	0.096
		InCong	high	45	0.649	0.156
			low	45	0.564	0.124
	Equal	Cong	high	45	0.509	0.128
			low	45	0.449	0.079

		InCong	high	45	0.644	0.156
			low	45	0.544	0.106
	HighISPC	Cong	high	45	0.501	0.121
			low	45	0.441	0.079
		InCong	high	45	0.648	0.178
			low	45	0.558	0.114
	LowISPC	Cong	high	45	0.578	0.149
			low	45	0.502	0.106
		InCong	high	45	0.649	0.142
			low	45	0.546	0.117
Sad	HighLWPC	Cong	high	45	0.514	0.131
			low	45	0.445	0.083
		InCong	high	45	0.698	0.163
			low	45	0.593	0.137
	LowLWPC	Cong	high	45	0.515	0.127
			low	45	0.451	0.083
		InCong	high	45	0.705	0.162

			low	45	0.603	0.147
	Equal	Cong	high	45	0.504	0.115
			low	45	0.448	0.078
		InCong	high	45	0.689	0.158
			low	45	0.586	0.130
	HighISPC	Cong	high	45	0.501	0.116
			low	45	0.439	0.079
		InCong	high	45	0.691	0.184
			low	45	0.623	0.146
	LowISPC	Cong	high	45	0.568	0.138
			low	45	0.500	0.094
		InCong	high	45	0.692	0.158
			low	45	0.565	0.132
Neutral	HighLWPC	Cong	high	45	0.520	0.136
			low	45	0.446	0.082
		InCong	high	45	0.706	0.172
			low	45	0.600	0.140

	LowLWPC	Cong	high	45	0.517	0.124
			low	45	0.453	0.087
		InCong	high	45	0.710	0.163
			low	45	0.592	0.135
	Equal	Cong	high	45	0.498	0.118
			low	45	0.448	0.076
		InCong	high	45	0.686	0.151
			low	45	0.598	0.136
	HighISPC	Cong	high	45	0.504	0.120
			low	45	0.439	0.077
		InCong	high	45	0.696	0.172
			low	45	0.626	0.143
	LowISPC	Cong	high	45	0.563	0.146
			low	45	0.502	0.091
		InCong	high	45	0.698	0.168
			low	45	0.563	0.125
Angry	HighLWPC	Cong	high	45	0.514	0.142

		low	45	0.446	0.086
	InCong	high	45	0.653	0.165
		low	45	0.559	0.124
LowLWPC	Cong	high	45	0.510	0.128
		low	45	0.452	0.090
	InCong	high	45	0.632	0.141
		low	45	0.553	0.121
Equal	Cong	high	45	0.501	0.131
		low	45	0.451	0.084
	InCong	high	45	0.632	0.145
		low	45	0.557	0.109
HighISPC	Cong	high	45	0.499	0.131
		low	45	0.441	0.085
	InCong	high	45	0.635	0.166
		low	45	0.561	0.117
LowISPC	Cong	high	45	0.572	0.154
		low	45	0.500	0.103

InCong	high	45	0.640	0.135
	low	45	0.548	0.119

Table 1 illustrates that descriptive analyses were conducted to examine mean accuracy scores and standard deviations across conditions defined by emotion (sad [566 ms], neutral [553 ms], happy [544 ms], and angry [537 ms]), proportion congruence type [High LWPC (615 ms), Low LWPC (607 ms), High ISPC (550 ms), Low ISPC (574 ms), and equal proportion (600 ms)], congruency[congruent (503 ms) and incongruent (675 ms)], and anxiety level[low anxiety (516 ms) and high anxiety (596 ms)]. Major trends overall, all emotions, and incongruent trials tend to have higher mean response times than congruent trials, as expected with a standard congruency effect. Those who have high anxiety had higher mean values on incongruent conditions than those with low anxiety, indicating an increased interference effect for high anxiety participants.

A repeated-measures ANOVA using RTs was conducted to examine the impact of main and within-subject factors and their interactions with anxiety. The results revealed a significant main effect of anxiety, $F(1, 88) = 10.02$, $p = .002$, $\eta^2_p = 0.102$, indicating that participants with high anxiety (0.596) differed significantly in performance compared to those with low anxiety (0.516). The main effect of anxiety was found to be significant, with $F(1, 88) = 10.02$, $p = .002$, $\eta^2_p= 0.102$, indicating that participants with low anxiety (516 ms) performed faster than high anxiety (596 ms) individuals. The main effect of emotion was found to be significant, with $F(3, 264) = 63.329$, $p < .001$, $\eta^2_p = 0.418$. The result suggests that overall, participants were faster for angry (537 ms) emotion, followed by happy (544 ms) and neutral (553 ms), and then slowest for sad (566 ms). The main effect of proportion congruence was significant, $F(4, 352) = 15.656$, $p <.001$, $\eta^2_p = .151$. This indicates that overall participants were fastest in the incremental order of RTs for conditions: High ISPC (550 ms), Low ISPC (574 ms), equal proportion trials (600 ms), Low LWPC (607 ms), High LWPC (615 ms). The main effect of congruence was significant, $F(1, 88) = 611.052$, $p <.001$, $\eta^2_p =.874$. The results indicate that participants were overall faster for congruent trials (503 ms) in comparison to incongruent trials (675 ms).

The two-way interaction between anxiety and emotion did not reach significance, $F(3, 264) = 2.320$, $p = .076$, $\eta^2_p= 0.026$.

The two-way interaction between anxiety and proportion congruence was significant, $F(4, 352) = 3.171$, $p = .014$, $\eta^2_p = 0.035$. This suggests that anxiety levels moderated the effect of proportion congruence on task performance. *Post hoc* comparisons indicate that high-anxiety participants (600 ms) were faster than low-anxiety participants (692 ms), $t(88) = 3.561$, $p = .027$) for the Low-ISPC condition.

High-anxiety participants in Low-ISPC (600 ms) compared to several other combinations, including low-anxiety participants in High-LWPC (742 ms) ($p = .003$), Low-LWPC (737 ms) ($p = .005$), and Equal (728 ms) ($p < .001$). This suggests that high-anxiety individuals performed best when reactive control was required.

The two-way interaction between anxiety and congruence was significant, $F(1, 88) = 9.220$, $p = .003$, $\eta^2_p = 0.095$, indicating that Stroop interference effects were modulated by participants' anxiety levels. The *Post hoc* comparisons indicate that a significant difference was found between high- and low-anxiety participants in the congruent condition, with high-anxiety (831 ms) individuals responding more slowly than low-anxiety (768 ms) individuals ($M = 0.063$, $SE = 0.022$, $t(88) = 2.800$, $p = .038$). This suggests that high anxiety was linked to slower performance when interference was low. In contrast, in the incongruent condition, high-anxiety (681 ms) participants responded significantly faster than low-anxiety (777 ms) participants (*M* = 0.096, *SE* = 0.028, *t*(88) = 3.364, *p* = .007). High-anxiety individuals were also significantly faster on incongruent trials (681 ms) compared to their own performance on congruent trials (831 ms) (*M* = -0.150, *t*(88) = -19.626, *p* < .001), indicating a strong performance boost in high-conflict conditions.

The two-way interaction of emotion and proportion congruence was significant, *F*(12, 1056) = 2.465, *p* = .004, η^2_p = 0.027, suggesting that the effect of emotion varied depending on the level of proportion congruence. The *Post hoc* comparisons indicate that a significant interaction was observed between emotion and proportion congruence, F(12, 1056) = 2.465, p = .004, η^2_p = .027, indicating that the effect of emotional primes on reaction times (RTs) varied depending on the level of proportion congruence. In Low-ISPC condition, participants responded significantly faster following Happy primes (663 ms) compared to Sad (699 ms, *p* < .001), Neutral (699 ms, *p* < .001), and Angry (683 ms, *p* = .024) primes. Additionally, responses were faster following Angry primes (683 ms) than Sad (699 ms, *p* = .013) and Neutral (699 ms, *p* = .030) primes. These findings suggest that both positive and threat-related emotions facilitated task performance when reactive control demands were high. In the High-LWPC condition, significant differences were also observed. Happy primes (661 ms) led to significantly faster responses than Sad (694 ms, *p* < .001) and Neutral (689 ms, *p* < .001) primes. Similarly, Angry primes (676 ms) elicited faster responses than Sad (*p* = .013) and Neutral (*p* < .001) primes. These results indicate that emotional priming influenced performance under proactive control demands, although the effects were less robust than in the Low-ISPC condition.

In the High-ISPC condition, participants responded faster to Happy primes (664 ms) compared to Sad (700 ms, *p* = .008) and Neutral (696 ms, *p* = .003) primes. Angry primes (682 ms) also led to significantly faster responses than Sad (*p* < .001) and Neutral (*p* < .001) primes. While several comparisons were significant, the magnitude of effects was generally smaller than in Low-ISPC. In the Equal proportion congruence condition. Although responses to Angry primes (681 ms) were faster than to Sad (700 ms, $p < .001$) and Neutral (695 ms, $p < .001$) primes, no significant differences were observed between Happy and other emotions (668 ms, $p > .05$ for all). This suggests a reduced emotional influence in balanced task contexts. In the Low-LWPC condition, participants responded significantly faster to Happy primes (662 ms) compared to Sad (700 ms, $p < .001$) and Neutral (696 ms, $p < .001$) primes. Angry primes (679 ms) also led to significantly faster responses than Sad ($p < .001$) and Neutral ($p < .001$) primes. These results indicate that Happy stimuli consistently elicited faster RTs than Sad and Neutral stimuli across all proportion conditions. In comparison, Angry stimuli tended to show faster RTs compared to Sad and Neutral, especially in ISPC conditions.

The two-way interaction of emotion and congruency was significant, $F(3, 264) = 55.423$, $p < .001$, $\eta^2_p = 0.386$, indicating that the Stroop interference effect varied across emotional conditions. The *Post hoc* comparisons indicate that in the congruent condition, no significant differences were observed between any of the emotional primes. This suggests that emotional valence did not influence response times when the task was low in conflict.

In contrast, the incongruent condition showed consistent and robust effects of emotional priming. All emotional primes led to significantly slower responses on incongruent trials compared to their corresponding congruent trials ($p < .001$ in all cases). This confirms the presence of a standard congruency effect across emotions.

Further, within incongruent trials, some differences between emotions emerged. Specifically, Happy priming (831 ms) resulted in significantly faster responses compared to both sad (873 ms, $p < .001$) and neutral primes (876 ms, $p < .001$). Angry priming (826 ms) also produced significantly faster responses than sad ($p < .001$) and neutral primes ($p < .001$). No significant difference was found between happy and angry primes during incongruent trials, suggesting these two emotional primes were equally effective at facilitating performance under high-conflict conditions.

There was also a significant two-way interaction of proportion congruence and congruency interaction, $F(4, 352) = 54.553$, $p < .001$, $\eta^2_p = 0.383$, indicating that the magnitude of the Stroop effect was influenced by the frequency of congruent trials. The *Post hoc* comparisons indicate that In the congruent condition, only one significant difference emerged: participants responded significantly faster in the High-ISPC block (648 ms) compared to the Low-ISPC block (713 ms) ($M = -0.065$, $SE = 0.004$, $t(88) = -16.250$, $p < .001$). No other pairwise comparisons between congruent conditions reached significance after correction. In contrast, the incongruent condition showed a consistent pattern of significantly slower responses across all proportion congruence. Participants in the High-LWPC block were significantly slower on incongruent trials compared to congruent ones ($M = -0.149$, $p < .001$), and similar effects were seen for Low-LWPC, Equal, High-ISPC, and Low-ISPC blocks.

The three-way interaction among emotion, proportion congruence, and congruence approached significance, $F(12, 1056) = 1.635$, $p = .076$, $\eta^2_p = 0.018$, suggesting a potential but non-significant modulation of Stroop effects by the combination of emotion and trial frequency.

The four-way interaction of anxiety, emotions, proportion congruence, and congruence was significant, $F(12, 1056) = 2.475$, $p = .003$, $\eta^2_p = 0.027$. This result indicates that the combined influence of emotion, proportion congruence, and congruency on performance was further modulated by anxiety level. The *Post hoc* comparisons indicate in the angry emotion condition, participants with high anxiety demonstrated pronounced Stroop interference effects in several blocks. Under Low-LWPC, high-anxiety individuals showed a large interference effect (*M* = -0.181, *SE* = 0.025, *t*(88) = -7.13, $p < .001$) with mean RTs of 831 ms on congruent trials and 650 ms on incongruent trials, while low-anxiety individuals also showed a significant but smaller effect (*M* = -0.102, *SE* = 0.009, *t*(88) = -11.48, $p < .001$) with mean RTs of 790 ms on congruent trials and 688 ms on incongruent trials. In the Equal block, high-anxiety individuals again displayed substantial interference (*M* = -0.193, *SE* = 0.026, *t*(88) = -7.54, $p < .001$) with mean RTs of 845 ms on congruent trials and 652 ms on incongruent trials, with low-anxiety participants showing significant slowing as well (*M* = -0.093, *SE* = 0.010, *t*(88) = -9.69, $p < .001$) with mean RTs of 821 ms on congruent trials and 728 ms on incongruent trials.

In the happy emotion condition, particularly in the High-ISPC block. High-anxiety participants exhibited a robust interference effect (*M* = -0.197, *SE* = 0.027, *t*(88) = -7.17, $p < .001$) with mean RTs of 861 ms on congruent trials and 664 ms on incongruent trials, with low-anxiety participants also showing slower responses on incongruent trials (*M* = -0.107, *SE* = 0.011, *t*(88) = -9.59, $p < .001$) with mean RTs of 841 ms on congruent trials and 734 ms on incongruent trials.

Other higher-order interactions between emotion by proporption congruence and anxiety; proporption congruence, congruence, and anxiety did not reach statistical significance.

Overall, the results indicate that emotion, proportion congruence, and congruency significantly affect performance, with anxiety showing selective moderating effects most notably on congruency and proportion congruence.

A repeated-measures ANOVA using stroop effect (SE) was conducted to examine the impact of main and within-subject factors and their interactions with anxiety. The results revealed a significant main effect of anxiety, $F(1, 88) = 9.220$, $p = .003$, $\eta^2_p = 0.095$.

There was a significant main effect of emotion, $F(3, 264) = 55.42$, $p < .001$, $\eta^2 = .074$, $\eta^2_p = .386$, indicating that reaction times varied significantly across different emotional priming conditions.

The main effect of proportion congruence was also significant, $F(4, 352) = 54.55$, $p < .001$, $\eta^2 = .111$, $\eta^2_p = .383$, suggesting strong modulation of performance based on control condition.

The interaction between anxiety and emotion was not significant, $F(3, 264) = 1.27$, $p = .284$, indicating that the effect of emotion did not differ substantially between high and low anxiety groups.

Similarly, the anxiety and proportion congruence interaction was insignificant, $F(4, 352) = 1.63$, $p = .165$.

However, there was a significant three-way interaction between anxiety, emotion, and proportion congruence, $F(12, 1056) = 2.48$, $p = .003$, $\eta^2 = .004$, $\eta^2_p = .027$. This indicates that the combined effect of emotion and control condition on cognitive performance differed between high- and low-anxiety groups.

The emotion and proportion congruence interaction approached significance, $F(12, 1056) = 1.63$, $p = .076$, suggesting a trend where the effect of emotional priming varied across control conditions, but this did not reach conventional significance.

Chapter 6. DISCUSSION

The present study aimed to investigate the impact of emotional priming on the Dual Mechanisms of Control (DMC) (Braver, 2012). More specifically, the research looked into the interaction between emotional priming (happy, sad, angry, neutral), cognitive control mode (proactive or reactive), and anxiety trait using a spatial Stroop paradigm.

The findings provide strong support for the role of emotional priming and anxiety in affecting the proactive and reactive cognitive control, as conceptualized within the Dual Mechanisms of Control framework (Braver, 2012).

Low-anxiety participants showed significantly faster reaction times in LWPC blocks and had smaller Stroop effects, indicating efficient use of proactive control. This supports our hypotheses suggesting that individuals with low anxiety are better able to use proactive control and engage in anticipatory control strategies.

Across both anxiety groups, participants demonstrated facilitation in LWPC blocks compared to ISPC and Equal conditions, suggesting that proportion congruency influenced engagement of proactive control regardless of emotional condition. This finding aligns with previous work by Gonthier et al. (2016), which emphasized the role of block-level congruency in affecting proactive control.

High-anxiety participants showed increased Stroop interference following high-arousal primes (happy, angry), specifically in ISPC blocks. This finding is consistent with Yang et al. (2018), who reported that anxiety impairs proactive goal maintenance but may increase transient reactive responding under emotionally salient conditions.

Notably, happy and angry primes, both high in arousal, were associated with smaller Stroop effects than low-arousal emotions (sad, neutral) in both LWPC and ISPC blocks. This also supports our hypotheses and suggests that emotional arousal may enhance both proactive and reactive control under specific task conditions. These findings support Visalli et al. (2023), who found that emotional priming modulates cognitive control depending on the changing goals and the environment.

Together, the results show that both trait anxiety and emotional priming affect cognitive control mechanisms, with the importance of both individual differences and emotional factors in executive functioning.

Chapter 7. CONCLUSION, IMPLICATIONS, LIMITATIONS, AND SCOPE FOR FUTURE RESEARCH

7.1 Conclusion

The present research offers clear evidence that anxiety levels and emotional priming affect the engagement of Dual Mechanisms of Control (DMC) in a spatial Stroop task. Happy primes showed an improved performance in most of the conditions, but sad and angry primes declined in control under high-demand conditions, especially for subjects with high anxiety. Angry primes produced slower RTs than neutral and sad primes under certain conditions, which indicated significant interference effects. Participants with high anxiety showed stronger support towards reactive control and increased awareness of emotion cues, whereas participants with low anxiety showed stable performance across all the conditions, which indicates balanced control engagement and better emotional regulation. These results help increase our knowledge of how emotional states and individual differences influence cognitive control.

7.2 Implications

These findings validate the hypotheses of the DMC model (Braver, 2012), which states that cognitive control is independent of each other in proactive and reactive modes and is further moderated by emotional priming and dispositional characteristics such as anxiety. The findings also generalize the hypotheses of Visalli et al. (2023), showing that emotional priming influences Stroop interference under different control demands.

In addition, the findings are part of the cumulative evidence that emotions and anxiety can change how well a person can focus depending on the nature of the task (Chiew & Braver, 2011; Yang et al., 2018). By simultaneously investigating four different emotions and dividing participants by different anxiety levels, the current study provides a more integrated picture of how emotions and personality traits like anxiety interact to impact cognitive performance.

7.3 Scope for Future Research

Involvement of participants with diagnosed mood disorders, anxiety disorders, or attentional deficits (e.g., ADHD) may help to paint a more detailed picture of how anxiety and emotional priming interplay with cognitive control processes in clinical situations.

Future research must investigate using immersive and dynamic emotional stimulation, for example, videos or virtual reality, to better model real-life conditions for the emotions.

Examining if emotion regulation training, mindfulness, or cognitive training can modulate the effects of emotional priming and enhance proactive control, particularly in those with high anxiety, would be of both theoretical and practical value.

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