Influence of Affective Priming Modality on Dual Mechanism of Control

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Submitted By

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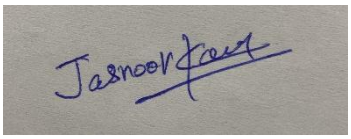
CERTIFICATE

This is to certify that the thesis titled, "Influence of Affective Priming Modality on Dual Mechanism of Control" is being submitted under the partial requirement for the award of the degree of Masters in Arts in Psychology, presented at Thapar School of Liberal Arts and Sciences, Thapar Institute of Engineering and Technology, Patiala. The work carried out under the supervision of Dr Richa Nigam, Assistant Professor, TSLAS and no part of this dissertation has been submitted for any other degree.



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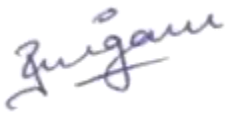

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Candidate's Declaration

I hereby declare that the thesis titled, "Influence of Affective Priming Modality on Dual Mechanism of Control" submitted under the partial requirement for the award of the degree of Masters in Arts in Psychology, presented at 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 guidance of Dr. Richa Nigam, Assistant Professor TSLAS, refers other researchers work mentioned in the reference section. The matter included in this dissertation has not been formed for the award of any other degree at this or any other institution.

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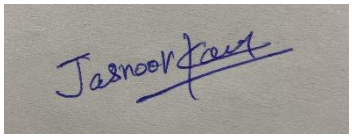

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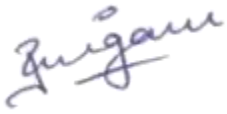

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Abstract

The study explored how prime types, emotional valence and proportion congruency influence Dual Mechanism of Control through a spatial stroop task. The study used a within subject design, the task used 2 primes (image & words), and 3 emotional valence (happy, neutral and sad), 5 proportion congruency (High LWPC, Low LWPC, Equal LWPC , High ISPC and Low ISPC) and congruence (congruent & incongruent) as within subject factors. 80 participants volunteered for this study and they were asked to perform a spatial stroop task preceded by exposure to emotionally valenced primes. The results found showed significant effects of prime, emotion, proportion congruence and congruence. Robust stroop effect was found as participants responded quickly to congruent trials in comparison to incongruent trials through all conditions. Emotional valence modulated interference with neutral primes leading to faster reaction time as compared to happy primes and sad primes overall leading to delayed reaction time during incongruent trials. Effect of proportion congruency also modulated its effect in incongruent trials significantly during High ISPC, Equal LWPC and Low LWPC conditions. The finding support the DMC framework, showing how emotions and proportion effect proactive and reactive control.

Keywords: Stroop task, Cognitive Control, Affective Priming, Proportion Congruency, Emotion regulation

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Chapter 1

Introduction

1.1 The Stroop Paradigm

The stroop task as first introduced by J.Ridley Stroop (1935), assess an individual's attention, inferential experience, memory and control processes. The inherent nature of the task involves conflict monitoring, conflict adaption and cognitive control in terms of proactive versus reactive control. Conflict monitioring refers to brain's ability to notice conflicting information and responding accordingly, Conflict adaptation refers to after monitoring the conflict how the brain adjusts behaviour to respond correctly by increasing attention and Cognitive control refers to automatic ability to work in goal directed behaviour.The general observations are in terms of an increase in reaction time and errors during incongruent trials as compared to congruent trials. This effect (in terms of the subtraction score of incongruent -congurnet RTs) is known as the **stroop effect**. This effect helps in measuring cognitive control, attention, and conflict resolution. While performing the task the participants experience conflict which is called conflict monitoring which occurs when faced with an incongruent trial. When the individual makes changes in his behavior to overcome the conflict, its called conflict resolution leading to conflict adaptation. When this adaptation occurs as a consequence of previous trial preparation, so that the individual is better prepared in the current trial, this is called as proactive control. In contrast to this, resolving the conflict as it comes, that is without any prior preparation is called reactive control. Both proactive and reactive control are parts of cognitive control which is the ability of the brain to regulate goal directed behaviour.

1.2 Cognitive Control and the Dual Mechanism Framework

Cognitive control refers to the ability to control and regulate our thoughts, behavior's, reactions and emotions towards goal directed behavior mostly in situations that require resolution of conflict or interference and decision making (Miller & Cohen,2001). Cognitive control helps individuals to adapt to changing environment, to suppress inappropriate automatic responses and to give attention to appropriate information. It plays an important role in inhibiting distractions, focusing on task relevant information and in handling interference from conflicting information.

Dual Mechanism of Control proposed by (Braver, 2012) explains that there are two types of cognitive control: proactive control and reactive control. These mechanisms help individuals to resolve conflicting information occurring in cognitive tasks.

Proactive Control: Also known as anticipatory control in this task relevant information is kept in mind while facing conflicting task so that individual responds in the goal directed behavior (Braver, 2012). This mode is activated overtime and depends on working memory to keep the relevant information in mind and allows the individual to be prepared for the upcoming cognitive demands. When proactive control is active the participants try to predict conflicts and make responses accordingly.

For example in Stroop Task with with high proportion congruency where 70% of the trials are congruent the participant is most likely to engage in proactive control to sustain his or her attention towards the goal directed behavior. This helps in inhibiting conflict and reduction in Stroop Effect. Neuroimaging studies have shown that proactive control occurs due to increase in the activation of lateral prefrontal cortex which is responsible for maintaining attention and preparing for upcoming stimuli or information (Braver, 2012).

Reactive Control: Reactive control gets utilized when the participant detects a conflict. It is stimulus driven and mostly gets activated after the appearance of the conflicting information. It gets evoked only when necessary such as when an incongruent trial occurs the focus shifts from maintaining the task relevant information in mind to responding to solve the conflict as it disrupts the performance (Braver, 2012). Also known as late correction as it gets activated after the appearance of the conflicting information and functions to temporary information rather than sustaining attentional state.

Reactive control gets activated easily when most of the trials occurring are congruent and participants keep the task relevant information in mind not anticipating a conflicting information to occur. If conflicting information suddenly occurs reactive control surpasses the automatic response mechanism in order to response correctly under interference. The brain area associated with this is anterior cingulate cortex which is responsible for detecting conflicting information and making adjustments (Botvinick.et.al., 2001).

Proactive and Reactive control are mostly studied as separate mechanisms but they are not specifically separate. Instead cognitive control shifts between them depending on the stimulus or information appearing (Gonthier et al., 2016). Which mechanism is mostly used depends on individual differences such as people who have high working memory tend to rely more on proactive control and others may depend on reactive control (Engle, 2002). Further the task requirements can also affect which mechanism is predominantly used.

Research based on emotional stimuli has shown individuals to fall towards either proactive or reactive control. Positive emotional states are often associated with proactive control as they increase flexibility and working memory capacity. Negative emotions on the other hand are

linked to reactive control as they increase attention to conflict and heightened adjustment in response selection. (Chiew & Braver, 2014).

The present study has tried to identify the effect on dual mechanism of control by seeing how emotional primes (Images and Words) affect attentional state in spatial stroop task. By incorporating both List Wise Proportion Congruency (LWPC) which implies to proactive control and Item Specific Proportion Congruency (ISPC) which implies to reactive control in the experimental design.

Through this we would get to investigate whether Image primes have stronger effect on Dual Mechanism of Control as compared to Word primes. Also if positive emotional primes have a stronger impact on Dual Mechanism of control or not.

In the past, Stroop Task has been adapted into many forms over the years (Hershman et al., 2024; Thompson et al., 2021;Viviani et al., 2023). One of these is the Perfovial or Spatial stroop task. In these, the participant responds according to the direction of the stimulus (anywhere in space) appearing on the screen, e.g. arrows pointing towards a particular direction either left or right. Congruence in these tasks is defined on the basis whether the arrow pointing towards a particular direction (lets say right) appears on that side of the screen as well or not. If the arrow points to the right direction also appears on the right side of the screen, this is called a congruent trial. However, for an arrow that points towards the right direction but appears on the left side of the screen, would be an incongruent trial (Lu and Proctor, 1995).

1.3 Operationalizing Dual Mechanism of Control in Stroop task using Proportion Congruency

In stroop paradigm proportion congruency effect is widely used. It refers to the proportion of congruent and incongruent trials that appear in a task which influences the performance. This

phenomenon is known as proportion congruency effect which provides insights into how it affects cognitive control (Bugg & Crump, 2012). Two categories of proportion congruency are List Wide Proportion Congruency (LWPC) and Item Specific Proportion Congruency (ISPC) which imply to proactive and reactive control respectively, described in Dual Mechanism of Control framework (Braver, 2012; Gonthier et al., 2016). In the current study, these manipulations are used to help identify how individuals regulate the attention and response accordingly, in tasks such as spatial stroop.

List Wide Proportion Congruency (LWPC): This manipulation occurs on a block level where the cognitive control gets affected by the proportion of congruent and incongruent trials occurring throughout the block. For example when the block consists of mostly incongruent trials there would be reduction in stroop effect in comparison to the block with mostly congruent trials. This manipulation implies towards proactive control where the participants anticipate the conflict apriori and adjust their attention according to it (Bugg et al, 2011). Proactive control as explained in Dual Mechanism Framework involves maintenance of goal relevant information in mind and giving response accordingly to reduce interference before it occurs (Braver, 2012).

Item Specific Proportion Congruency (ISPC): Item Specific Proportion Congruency implies to reactive control and its manipulation occurs at an item level. In this case specific items are can either be a congruent or an incongruent trial. Participants can learn these items overtime leading to reduction in stroop effect. (Bugg & Hutchisom, 2013). In this form of stratergy ractive control gets activated in response to conflict when it occurs.

In stroop task ISPC effects make the participants more attentive to focus on the location of the specific stimuli. For example if a specific item causes conflict continuously, participants learn to

give that item more cognitive control. This helps them to respond correctly while using minimal cognitive cost (Bugg & Crump, 2012).

The difference between LWPC and ISPC aligns with Dual Mechanism Framework which states that proactive control is attention driven (operationalised by LWPC trials manipulation) and reactive control is stimulus driven (operationalised by ISPC trials Braver, 2012). Lwpc manipulation assess proactive control whereas Ispc manipulation are learned through reactive control. Both these effects can occur together and also independently. ISPC effect has been found to occur independently in the absence of LWPC which shows there distinct control process (Bugg et al, 2015).

Founding's from Gonthier et al, 2016 study was able to found this disassociation, where they found that some individuals show strong list wide adjustments and others show more inclination towards item specific manipulations. His paper was able to find this distinction on the same set of people which shows hoe control mechanisms are different for different individuals at different levels of conflict.

1.4 Affect and Cognitive Control

Affect seems to play a vital role in modulating cognitive control (Chau et al., 2024)). In this regard, an emotional stroop task can be used to explore whether emotionally salient stimuli facilitates or interferes with cognitive control (Si, 2024)Within this context, emotionally valenced words or images appearing on the screen affect the attention of the participant differentially (Williams.et.al., 1996). As such the result show an increase in reaction time

specifically when the participant is faced with negatively valenced stimuli in comparison to positive stimuli (Hsieh and Sharma, 2019).

Emotions in stroop task can be embedded in the the stimulus itself like the researches discussed so far (Nigam and Kar, 2021). Or the emotions can also prime the stroop trial to have an effect (Raschele et al., 2017). While the images have been used so far to found a standard interefering effect of negative valence on cognitive control, there hasn't been any effort to compare the same with affective word primes.

1.5 Affective Priming and Emotions

Affective priming refers to a phenomenon when emotionally valenced stimuli (primes) are shown to the participant's it leads subsequent effect on the response to the target stimuli. Primes of any kind whether images or words can effect cognitive control by hindering attention and affecting behavioral response (Spruyt et al., 2003). Affective priming operates on the mechanism that it is mostly followed by a target stimuli. For example a prime of any valence would appear before the target stimuli to facilitate faster or slower processing of information. For example if a positive valence prime is presented and just after it a positive (hence congruent target) appears it would lead to a faster reaction time in comparison to a incongruent trial which would lead to increase in reaction time (Ferre & Sanchez Casas, 2014). Studies on affective priming effects have also found that priming effects are also observed when the primes are presented for a very short duration or are presented very slightly or outside the focus of our consciousness (Spruyt et al., 2003), which shows that there is involvement of both automatic and controlled mechanisms.

The present study makes use of both images and words of different valence (positive, negative and neutral) as primes to determine the effect each has on Dual Mechanism of Control.

Most of the previous literature has focused on making use of negatively valenced primes due to their capacity to effect cognitive processes strongly. The effect of positive emotions has not been researched much but it is now gaining attention for its facilitating effects on attentional flexibility and cognitive control (Rowe et al., 2007). According to Fredrickson's broad and build theory positive emotions promote cognitive and behavioral sources which promotes adaptive functioning. Positive affect increases attention which allows individuals to focus on task relevant information and in shifting between tasks. In a study conducted by Chiew and Breaver (2014), in which positive emotion and reward motivation were found to have divisible effect on cognitive control. Positive affect was associated with increased proactive control which keeps the focus on goal relevant information. Study by Wouwe et al.,(2011) also reported similar results that positive affect leads to better flexibility in cognitive shifting and adjustment to conflicting information. The findings show the importance of positive affect priming as it promotes more adaptive control strategies.

In addition to affect, Schuch and Koch (2015) showed that mood states also affect how one resolves conflicting information. In their study, they showed that participants in conflicting mood were easily able to resolve conflicting information in comparison to those in negative or neutral moods.

Given the extant researches so far, dual mechanism of control is explored using varying proportion congruence in the context of variable types of affective primes that are images versus words. In other words, the current research aimed to manipulate both LWPC and ISPC conditions within The Stroop Task and investigated how affective primes (Images and Words) influence Dual Mechanism of Control. The study aims to find if affective prime's specifically positive primes have an effect on proactive and reactive control or not. This study builds on

previous finding's to bring about a novel perspective on Dual Mechanism of Control as a fucntion of positive (versus negative and neutral) emotions and word primes (versus picture primes) to gain insight into DMC framework.

Chapter – 2

Literature Review

2.1 Introduction Dual Mechanism of Control in the Stroop Paradigm

Cognitive control is the ability to regulate thought and action in the face of conflicting information or distraction. The spatial stroop task uses spatial features of arrow direction and location to study interference. The participants task is to respond to the direction where the arrow is pointing towards and press the keys accordingly. (MacLeod,1991) conducted a meta-analysis which involved summaries of fifty years of research on stroop interference, and concluded that interference arises when irrelevant information interferes with the task relevant information. The study also mentioned how task manipulations such as congruency proportions can effect performance. The proportion congruency manipulation are LWPC & ISPC where in Lwpc participant expects mostly congruent trials and in Ispc congruency is varied across items. Braver,2012 conducted a study to support this model using neuroimaging and behavioral studies. The review included studies using tasks such as Stroop Task and Go NO-GO task to illustrate how participants used one control over the other. This review also stated that manipulations such as congruency proportions or presence of cues can shape how individuals rely on which control more.

When proportion congruency is manipulated participants have to adjust there cognitive control according to the condition or stimuli they are seeing which effects there behaviour Lwpc and Ipsc manipulations lead individuals to focus more or respond quickly after seeing the stimuli. s

The proportion congruency manipulations align with the DMC model. As List wide (LWPC) in which most of the trials are congruent implies to proactive control as it involves increase in

attentional focus. Item specific (ISPC) implies to reactive control as the participants get attentive after seeing the conflicting stimuli and respond accordingly.

2.2 Impact of Emotional Priming on Cognitive Control.

Affective Priming has been used to study how emotions study how emotions effect cognitive control. Emotionally valenced primes can impact attention and memory that can effect task performance. Study conducted by Kanske and Kotz, 2011 tested how emotional valence influences cognitive control in conflicting tasks. They aimed to determine whether emotionally valenced stimuli impair or facilitate conflict resolution. They recruited 26 participants for this study who performed flanker task while undergoing fMRI scanning. The stimuli was of emotional words (positive, negative and neutral) which flanked congruent or incongruent words. The resulting scans showed activation of anterior cingulate cortex and dorsolateral prefrontal cortex indicating that negative emotions impair conflict resolution whereas positive emotions facilitate it.

A study by Padmala, S., & Pessoa, L. (2010) explored that interaction between cognition and motivation during response inhibition. The objective was to explore affective and motivational stimuli effect cognitive control during a stop signal inhibition task. 21 participants were recruited for this study. They used a mixed design for this study in which the participants performed the stop signal task while they were primed with cued which showed winning or losing gains. The results showed that motivational cued enhanced performance when participants were cued with gains. The studies provide empirical evidence about the strong influence of emotional priming that effect cognitive control mechanisms.

However, most of these studies have explored DMC using image primes. In contrast to this, traditionally emotional priming tasks uses emotionally charged task relevant words that lead to have an effect on responses in an emotional face word stroop task. However images may evoke a stronger reaction in comparison to words due to presence of stronger affective response and ability to activate stronger neural reactions (Hilton & Kuhlmeier, 2019b) . Studies have further found that image primes of emotional faces or scenes have a stronger effect on attention leading to delayed reaction time, showing stronger priming effect of images than words (Carroll and Young, 2005). In a study by Flaisch et al (2015) wanted to investigate how the brain processes emotional stimuli under varying attentional conditions. For this study a sample of 29 people was taken. The participants were made to view stroop stimuli in which words were displayed over pictures and FRMI scan was conducted to measure brain activity during it. The results showed picture categorization task led to activation of visual parietal temporal and subcortical regions whereas word task led to activation of left extrastriate cortex. The results showed that emotional valence of images can effect cognitive control mechanism.

On the other hand verbal processing of emotional stimuli makes use of semantic networks in the brain and shows affects accordingly. It was found that word primes have a moderate effect and it depends on the intensity of the word being used, for example words like ‘violence, danger’ would have a stronger impact than words such as ‘love, happy’. Word primes are no doubt subtle and weaker to evoke sudden emotional reaction but they still activate affective reactions which effects cognitive control (Ferre and Sanchez casas, 2014). Therefore, current study finds the picture versus word primes of same intensity as an interesting facet to explore the influence of affect on Dual mechanism of Control.

2.3 Emotionally Valenced stimuli and Proportion Congruency

There have been several studies which have explored the effect of emotional valence on cognitive control through the stroop paradigm which includes manipulations of proportion congruency. Through these studies researcher can distinguish between the cognitive control mechanisms. When an individual is exposed to an emotionally charged stimuli be it positive or negative it can have an impact on proactive and reactive control. Two main manipulations in this domain are List Wide Proportion Congruency (LWPC) and Item Specific Proportion Congruency (ISPC). Which basically means to the manipulation of proportion of congruent and incongruent trials at block level or item level.

A study by J. R. Schmidt and Lemercier (2018) investigated whether stroop performance was modulated by list wide and item specific contingencies or not or whther these effects reflected learned contingencies or control based mechanisms. The study was conducted on 60m middle school students who were made to perform a color word stroop task in which some items were mostly congruent or mostly incongruent and list context manipulated overall congruency proportions. The results showed findings that item specific proportion congruency had effect even when controlling contingency learning. These findings suggest that proactive control can be engaged under highly conflicting conditions.

Study by Gonthier.et.al (2016) investigated whether both the mechanisms can occur independently or not. The study was conducted on two groups one group consisted of 35 undergraduate students and the group consisted of 58 people. The study used a within subject design and the experiment consisted of three blocks. 1st and 2nd block consisted of mostly congruent and mostly incongruent trials which was for LWPC manipulation. And the 3rd block was for ISPC manipulation which consisted of both items intermixed. The participants were

made to perform a stroop task, the stimuli consisted of animal pictures. The results showed that LWPC effect significantly reduced Stroop interference when faced with incongruent trials. And ISPC effect reduced during high control demands indicating reactive control. The findings suggested both the mechanism can occur independently in same participants under same conditions. Similar study by Vissali.et.al (2023) investigated the effect of emotional valence in cognitive control. For this study they recruited 74 participants. The study used a within subject design. The participants were made to do a spatial stroop task in which before every trial they saw an emotionally charged image (negative or positive) then the stroop trial occurred. The task was divided into 6 blocks. The LWPC conditions was manipulated at the block level such that 1ST and 5th block were of High LWPC (70% congruent), 2nd and 4th of Low LWPC (70% incongruent) and 3rd and 6th block of Equal LWPC9 (50% congruent and incongruent). ISPC manipulation was manipulated within the blocks. The findings showed increase in reaction time when the participants saw a negative stimuli.

These studies provide evidence that proportion congruency are sensitive to emotional context and can manipulate the results. Positive emotion can facilitate processing whereas negative stimuli can delay response time. Therefore the interplay between emotions and proportion congruency are important to understand dual mechanism of control.

2.4 Theoretical Integration

Throughout the reviewed literature a consistent pattern emerges that emotionally valenced stimuli whether words and images modulate cognitive control mechanisms. The modulation of the task the type of stimulus and the context of task demands are all important factors. Both the types of cognitive control that is proactive and reactive control get activated depending on the

task demand, situational and motivational factors. The mentioned studies give strong balance between all these control staretergies.

Studies on traditional and spatial stroop tasks (Banich et al.,2009; Egner et al., 2007; Braem et al., 2019) found that congruency manipulations such as LWPC and ISPC can clearly differentiate proactive and reactive control mechanisms. Lwpc findings suggest to activation of proactive control by focusing on the stimuli whereas Ispc effect leads to activation of reactive control to resolve the conflict after its occurrence. These manipulations are important to understand how control mechanisms are dynamically adjusted due to affective priming.

CHAPTER 3

Rationale, Research Gap, Objective and Hypothesis

3.1 Rationale and Research gap

The Dual Mechanism Framework says that cognitive control operated via two different mechanisms. These mechanisms can be both dissociating and associating using stroop task as the conflicting paradigm and using proportion congruencies as the manipulations to see the effect (Bugg & Crump, 2012). While these manipulations have already been used in previous studies very less emphasis has been given on positive affective priming. Previous studies have shown that negative valence emotional primes have an effect on attentional control and often lead to increase in reaction time and interference (van Steenbergan et al., 2010). The role of positive emotions remains understudied, in spite of evidence in research showing its role in increasing cognitive flexibility and promoting attention (Cohen et al., 2012). This mostly effects proactive control as it promotes goal directed behavior.

Aadditionally Image based priming studies have been used adversely, but there has been very limited use of words as primes. Word processing may be a slower process but it remains unclear whether they engage control mechanisms to the same extent as emotional image primes (Schulz et al., 2020). This gap provides the opportunity to explore the effect of words and image primes, to see which one has a stronger influence on DMC Framework. The current study hence includes all these dimensions of using emotional valence image and words (positive, negative and neutral). And control manipulations of List wide proportion congruency and Item specific proportion congruency. By using these manipulations the study aims to fill this research gap and offer theoretical and practical evidence into the working of cognitive controls.

3.2 Objectives

1. To see the effect of affective priming on Dual Mechanism of Control, specifically positive priming, in comparison with negative and neutral priming.
2. To compare the effect of image versus word prime on the Dual Mechanism of Control.

3.3 Hypotheses

1. Word primes would influence on Dual mechanism of control more in comparison to Image prime.
2. Positive valence would facilitate dual mechanism of control in comparison to neutral and negative valence.

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 (Blair et al. 2007; Nigam and Kar et al. 2021; Vissalli et al., 2023), the expected range of effect sizes was between ηp^2 =.20 and ηp^2 =.70 for the effect of age and conflict adaptation on measures of interest. In order 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 40 participants. Still, it should be noted that G*Power (and, to the best of our knowledge, all other software commonly used to compute power) does not support power calculation for general linear model effects including both multiple within-subjects factors and continuous covariates

. Informed consent was taken from all the participants prior to their participation in the study and task was carried out in accordance to the guidelines of the IRB committee. 80 participants (Mean age : 21 years; 41 females) from Thapar University volunteered to participate in the study.

4.2 *Design*

For the present study and Within Subject Design was used. Independent Variables were Prime (Image versus Words), Emotions (Positive, Negative and Neutral) and Proportion Congruency: (High LWPC, Low LWPC, Equal LWPC, High ISPC and Low ISPC,) and Congruency (Incongruent and Congruent). Dependent Variables were

Reaction Times, Error Rates and Stroop Effect.

4.3 ***Stimuli***

Emotional Prime Images of varying valence (Positive, Negative and Neutral) were used in the study. Out of 40 images, post rating by 30 raters (Mean age:22.years), a total of 20 prime images were selected for this task, 10 of males and 10 of females. The images were standardised by having them rated and matched on the basis of intensity on a scale of 1-5, $t(58) = .-1.052$, $p = .297$ Eventually, 30 images (10 of each valence) were then incorporated into the final experimental design. Similar to images, a total 34 words were pre-rated by 30 raters (mean age: 22years). Out of these a total of 30 words were selected (10 in each valence) $t(18) = -6313$, $p = <.001$(neutral v/s sad), $t(18) = -9.173$, $p = <.001$(neutral v/s happy), $t(18) = -1.050$, $p=.308$ (happy v/s sad) on the basis of intensity on a scale of 1-5.

4.4 *Procedure:*

The task was inspired by Vissalli et al. (2023). The participants were required to sit in front of a computer at a distance of 60cm from the screen of a 19” monitor. The task was presented using psychopy software. Each trial in the experiment began with a black fixation cross against a grey background at the centre of the screen for 500ms. This was followed by an emotional prime presented at the centre of the screen for 600ms. This was followed by another fixation cross which appeared for 400 ms then stroop task appeared for 2000 ms. For this task spatial stroop images were used which consisted of directional arrows against the grey background. The participant had to respond to the direction of the arrow (upper left, right or lower left and right) on the screen thereby forming congruent (arrow pointing at the right direction in the corner) or incongruent (arrow pointing at the opposite direction from the corner). The keys they had to

press were as follows: '**e**' for upper left direction, '**d**' for lower left direction, '**o**' for upper right direction and '**k**' for lower right direction. The participants had to respond according the direction of the arrow (arrow head) the task relevant information, ignoring the spatial location of the arrow. The congruent condition referred to if the arrow pointed towards the corner of the screen and incongruent trials referred to if the arrows pointed in the opposite direction.

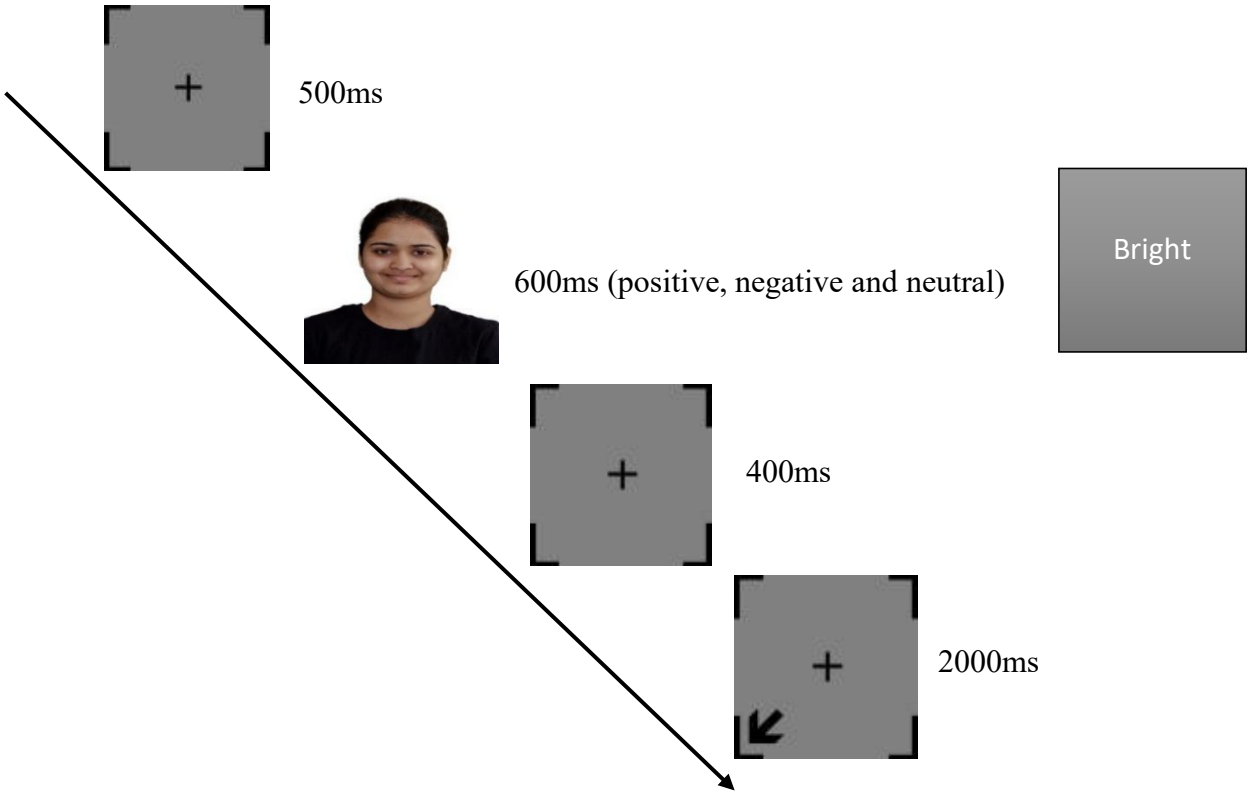
The experiment was conducted in two phases first phase consisted of IMAGE PRIMES and second phase consisted of WORD PRIMES. Both phases had 3 parts one feedback part and two testing parts. Both the testing parts had 6 blocks each block having 60 trials. There were breaks after every 3 blocks and total of 360 trials per phase were used in this experiment.

List Wide Proportion Congruency (LWPC) and Item Specific Proportion Congruency (ISPC) conditions both were manipulated within the same blocks. LWPC was manipulated at the block level as HIGH LWPC (70% congruent and 30% incongruent), LOW LWPC (70% incongruent and 30% congruent) and EQUAL LWPC (50% congruent and 50% incongruent). ISPC was manipulated by having a specific item either being congruent or incongruent for most of the trials. The blocks were divided on the basis of proportion that is 1st and 5th block were of HIGH LWPC, 2nd and 4th block were of LOW LWPC and 3rd and 6th block were of Equal LWPC.

The experiment took approximately 30 minutes to complete. After filling out of the consent form. The experiment began with instructions being displaying on the laptop screen. After explaining the instructions to the participant the experiment was started. In the feedback phase participants were given feedback if they had responded correctly or incorrectly. Participants were given breaks after each part. The experimental design was as such in the – a fixation cross appeared on the screen for 500ms, then a PRIME (positive, negative or neutral) appeared on the screen for 600ms, then again a fixation cross appeared on the screen for 400ms, after which a

stroop image either congruent or incongruent appeared for 2000ms after which participant had to respond to the direction the arrow appearing on the screen by pressing the keys ‘e’ for upper left direction, ‘d’ for lower left direction, ‘o’ for upper right direction and ‘k’ for lower right direction then a blank appeared for 500ms after which the new trial began. Primes were counterbalanced among participants some participants saw image prime first then word prime, others viewed primes in reverse order, so as to prevent order effect.

TRIAL STRUCTURE



4.5 ***Software***The experiment was built on Psychopy software and SPSS Software was used for data analysis.

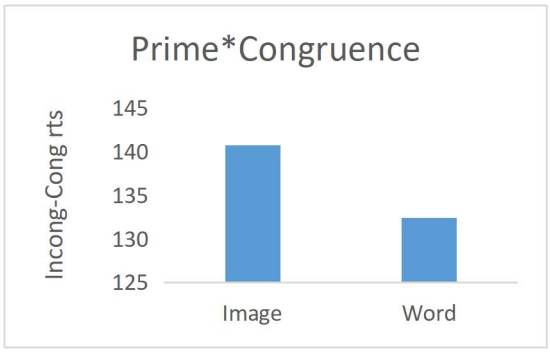
Chapter-5 Results

Statistical Analysis of Linear Mixed Model was used to examine the effect of Prime Type (Image v/s Word), Emotional Valence (Positive, Neutral & Negative), Congruence (Congruent & Incongruent), LWPC (High, Low & Equal) and ISPC (High & Low) on Reaction Time. Participant ID's were used as random effects. All intercepts were used in a with-in subject design.

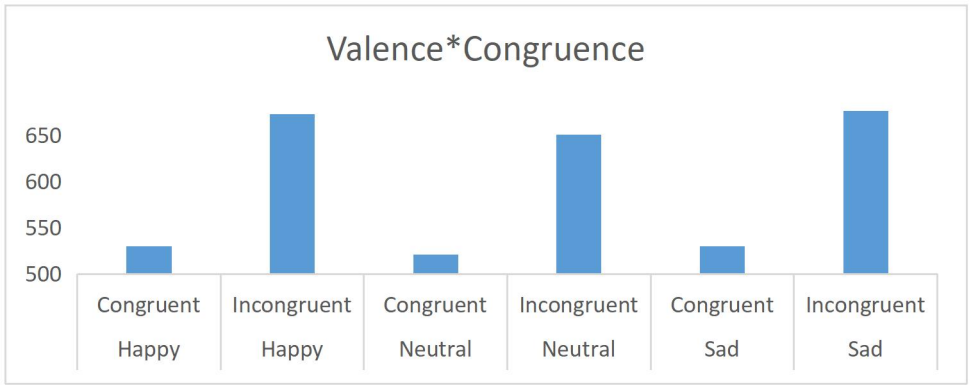
The main effect of prime was found to be significant with $F(1,79.24) = 4.897$ p=.027 indicating that prime had an effect on participants reaction time with Image Primes producing slowing reaction time (600ms) than Word Primes (596ms).The main effect of valence also came significant with $F(2,55781.016) = 22.777$ p<001. The results suggest that neutral prime (590ms) led to faster responses in comparison to happy (601ms) and slowest reaction time for sad valenced prime (603ms)

The main effect of congruence was also found significant $F(1,55781.144)=6162.417$ p=<.001 The results show a robust stroop effect with response being faster for congruent trials (530ms) and slower for incongruent trials (667 ms).The main effect for Item Specific Proportion Congruency came significant $F(1,55781.035)=66.040$ p<.001. The results suggest that the participants responded slower for Low Ispc (605ms) in comparison to High Ispc (591ms). The main effect of List Wide Proportion Congruency also came significant $F(2,55781.017)=10.157$ p =<.001. The results suggest that participants showed faster responses to Equal Lwpc (593ms) then High & Low Lwpc (603ms).

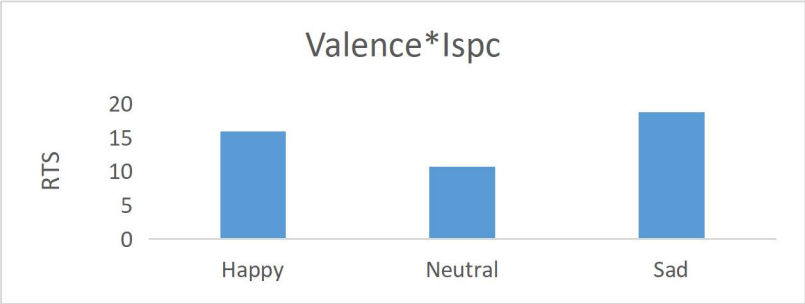
The two-way interaction of prime and congruence also came significant $F(1,55781.039) = 5.741$p=0.17 suggesting that Prime type modulated participants reaction time. *Emmeans* results suggest that Image primes led to slower reaction time (140.706ms) as compared to Word prime (132.737ms).



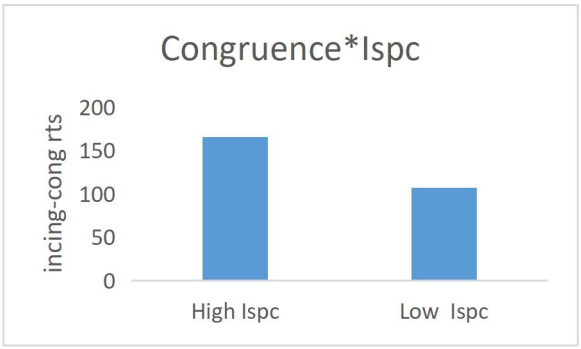
Significant two-way interaction of valence and congruence came out $F(2,55781.018) = 21.066$ p=<.001. The results suggested that in each valence Stroop effect was present for each emotional valence (all p<.001). The stroop effect was found to be the highest in happy valenced primes (142.90ms) and then sad valenced primes (146.12ms). The stroop effect was smallest for neutral primes (120.70ms).



Another significant interaction two-way interaction of valence and ispc $F(2,55781.012)= 3.612$ p = .027. *Emmeans* found that the difference in reaction times were largest under happy valence (15.922ms) followed by sad valence (18.738ms) than for neutral primes (10.735ms).

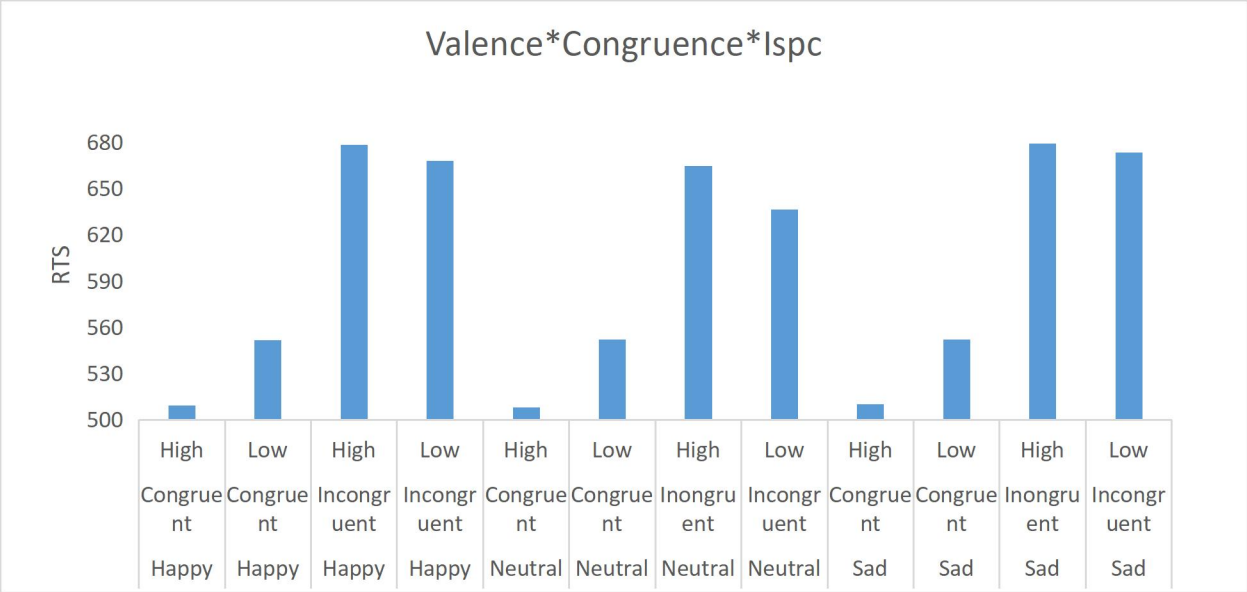


Significant interaction effect was found for congruence and ISPC, $F(1,55781.117) = 270.053$. $p < .001$. *Emmeans* results suggested that responses were slower under high Ispc condition trials (165.593ms) in comparison to low ispc condition trials (107.485ms).



Significant three-way interaction for valence, congruence and ISPC $F(2,55781.024)=4.620$ $p=.010$.Suggesting that emotional valence and ISPC effect the response time to stroop stimulus. *Emmeans* suggest that for happy primes reaction time was faster under high ispc condition (M=509.068ms) than low ispc (551.422ms) and for incongruent trials responses were faster under low ispc condition (M=667.898ms) than in high ispc condition (M= 678.407). For neutral primes similar effects were found where congruent trials in high ispc led to faster response (M=507.797ms) than low ispc (M=551.949ms) and for incongruent trials responses were faster

under low ispc condition (M=636.235) than for high ispc (M= 664.917). For sad primes the results, participants again responded faster to congruent trials in high ispc condition (M=508.899ms) than low ispc condition trials (M= 551.949ms). For incongruent trials the reaction times came almost similar in high ispc condition (M= 679.218ms) and for low ispc trials (M= 673.644ms).



A significant four-way interaction was found between Emotional Valence, Congruence, ispc, andlwpc, $F(4, 55{,}781.02) = 3.15$, $p = .013$, indicating that both reactive and proactive control mechanisms were modulated by the emotional content of the prime. For happy primes response times on congruent trials were fastest under high ispc and equal lwpc (M = 506.13 ms), and slowest under low ispc and low lwpc(M = 561.29 ms). Incongruent RTs for happy primes were shortest for (low ispc, equal lwpc: M = 659.99 ms), and longest under high ispc with equal lwpc (M = 676.02 ms), suggesting optimal control when conflict expectancy was high. For neutral primes congruent responses were fastest under high ispc and equal lwpc (M = 501.87 ms) and

slowest under low ispc and equal lwpc (M = 556.45 ms). On incongruent trials, neutral stimuli showed a reversed pattern: the fastest responses occurred under low ispc and equal lwpc (M = 623.76 ms), while high ispc conditions, low lwpc) yielded slower responses (M = 669.61 ms). This suggests that high reactive control may not always benefit conflict resolution when the prime is emotionally neutral, and proactive control may instead dominate. For sad primes congruent trials faster responses for high ispc under equal lwpc (M = 510.87 ms), while low ispc with high lwpc produced slower responses (M = 556.54 ms). Incongruent trials under sad priming revealed nearly identical RTs under both control conditions: M = 669.568 ms (high ispc, equal lwpc) and M = 682.62 ms (low isoc, low lwpc), implying that control strategies were less effective for negative primes when conflict was present.

Table No. 1 Summary output of LMM results

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	79.247	1876.665	**.000**
PRIME	1	55781.162	4.897	**.027**
VALENCE	2	55781.016	22.777	**.000**
CONGRUENCE	1	55781.144	6162.471	**.000**
ISPC	1	55781.035	66.040	**.000**
LWPC	2	55781.017	10.157	**.000**
PRIME * VALENCE	2	55781.016	1.425	.241
PRIME * CONGRUENCE	1	55781.039	5.741	**.017**
PRIME * ISPC	1	55781.025	.428	.513
PRIME * LWPC	2	55781.016	.031	.970
VALENCE * CONGRUENCE	2	55781.018	21.066	**.000**
VALENCE * ISPC	2	55781.012	3.612	**.027**
VALENCE * LWPC	4	55781.018	1.331	.256
CONGRUENCE * ISPC	1	55781.117	279.053	**.000**
CONGRUENCE * LWPC	2	55781.022	.325	.723
ISPC * LWPC	2	55781.018	2.911	.054
PRIME * VALENCE *	2	55781.017	.714	.490

CONGRUENCE				
PRIME * VALENCE * ISPC	2	55781.016	2.093	.123
PRIME * VALENCE * LWPC	4	55781.018	1.003	.404
PRIME * CONGRUENCE * ISPC	1	55781.066	.026	.872
PRIME * CONGRUENCE * LWPC	2	55781.018	1.114	.328
PRIME * ISPC * LWPC	2	55781.015	.121	.886
VALENCE * CONGRUENCE * ISPC	2	55781.024	4.620	**.010**
VALENCE * CONGRUENCE * LWPC	4	55781.022	1.447	.216
VALENCE * ISPC * LWPC	4	55781.017	.660	.620
CONGRUENCE * ISPC * LWPC	2	55781.020	.081	.923
PRIME * VALENCE * CONGRUENCE * ISPC	2	55781.021	1.323	.266
PRIME * VALENCE * CONGRUENCE * LWPC	4	55781.017	1.602	.171
PRIME * VALENCE * ISPC * LWPC	4	55781.025	.503	.733
PRIME * CONGRUENCE * ISPC * LWPC	2	55781.021	2.019	.133
VALENCE * CONGRUENCE * ISPC * LWPC	4	55781.017	3.150	**.013**
PRIME * VALENCE * CONGRUENCE * ISPC * LWPC	4	55781.015	.796	.527

Chapter – 6 Discussion

The present study aimed to investigate how affective priming (Image v/s Words) modality od varying valence (happy, neutral & sad) influence dual mechanism of control using spatial stroop paradigm. Particularly in the context of using List wide proportion congruency and Item specific proportion congruency.

Significant main effect of prime type revealed that image primes led to slower responses in comparison to word primes. This supports our hypothesis that word based primes influence Dmc. Word primes being more concrete, abstract and easily linguistically processed, led to more engagement of top down process facilitating quick decision making (Jefferies et al., 2008b). Image primes lead to activation of broader attention networks but the salient and complex nature of introduces greater cognitive interference, increasing cognitive interference (Hinjoso.et.al.,2015). The main effect of emotional valence showed that neutral primes led to faster responses and better performance across all conditions in comparison to happy and sad primes, producing slowest responses. The results contradict our second hypothesis but are in alignment with previous researches which stated that emotional stimuli specifically negative ones divert attentional resources and impair task relevant processing (Pessoa, 2009). Happy valence primes may also broaden attention span too much and may also engage in additional processing pathways associated with reward and attention (Kanske & Kotz,2011). Neutral primes on the other hand are less emotionally engaging and allow for better performance by minimizing affecting interference and allowing better cognitive flexibility (Pessoa, 2009).

The strong effect of congruency confirms classic stroop effect where congruent trials led to faster responses in comparison to incongruent trials. Main effect of ISPC and Lwpc validate the presence of proactive and reactive control mechanisms. Participant responded faster under high

ispc in comparison to low ispc, indiciating faster reactive control (Buggg et al,2008) which stated that exposure to specific congruency proportion enhances adjustment. Equal Lwpc produced faster responses in comparison to High and Low Lwpc. suggesting a state of reduced expectancy biad (Braver,2012) suggesting proactive control can be modulated based on context.

Two way interactions of prime*congruence suggest that type of prime modulates the performance on stroop task. The interference was found larger under image primes, implying greater disruption for for emotionally rich stimuli and that images may elicit botton up interference (Pessoa, 2009).Valence*congruence interaction shows that stroop effect was slowest under neutral valenced primes. The results suggest the disruptive nature of emotionally valenced stimuli on attention.

Valence*Ispc interation further shows that emotional primes interact at item level. For all three emotions High Ipsc led to faster response time. Greater reactine time differences were found in happy and sad primes suggesting reactive control adaptations are more pronounced under emotional loading (Chiew and Brvaer,2011). Congruence*Ispc interaction also shows supportive reactional control modulation (Bugg et al., 2008). Larger stroop effect under High ispc condition suggests strategic adjustments in processing of congruent v/s incongruent trials when congruency is predictable.

Three way interaction of Valence*Congruence*Ispc shows influence of emotional valence on stroop performance is moderated by proportion of congruence at specific level. Under neutral primes again partcipants showed better performance followed by happy primes. Neutral and happy primes showed clear Ispc effect in congruent trials. This shows that participants switch between control depending on congruent and item level manipulations. Participants probably

used control cues to guide reactive control, our findings extend this by demonstrating emotional content can modulate this adaptation (Bugg and Crump, 2012).

Valence*congruence*Ispc*Lwpc interaction showed that both reactive and proactive control mechanisms were influenced by emotional valence. Neutral primes again showed cognitive flexibility showing adaptability to proactive control and happy primes showed faster rts under High Ispc and Equal Lwpc showing conflict adaptation. Sad primes primes overall showed hindered performance in incongruent trials. This aligns with the findings that negative emotions can impair conflict (Kanske,2012).

The results support DMC framework (Braver,2012), showing that cognitive control is highly flexible and dynamically modulated by task complexity and affect.

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Chapter-7

Conclusion

In conclusion the findings support the hypothesis that word primes facilitate cognitive control more in comparison to image primes. Word primes produced faster reaction times, suggesting they allowed for better engagement towards goal directed behavior leading to less interference. This aligns with previous theories that that say that verbal stimuli are less distracting and help in more controlled processing. Furthermore the interaction of LWPC and ISPC were found to be different mechanisms and are differently effected by emotional context. Overall this study adds to the DMC framework by suggesting modality and emotional context of primes together influence conflict resolution, with word primes offering an advantage in maintaining task relevant focus under cognitive demands.

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