Exploring associations between response inhibition and emotion: Effects of valence, motivation, information processing style and emotional reactivity

by

Martyn Sean Gabel

A thesis

Presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Doctor of Philosophy

in

Psychology

Waterloo, Ontario, Canada, 2021

Examining Committee Membership

The following served on the Examining committee for this thesis. The decision of the Examining Committee is by majority vote.

External Examiner	John Eastwood, Ph.D.
Supervisor	Tara McAuley, Ph.D.
Internal Members	Jonathan Oakman, Ph.D.
	Christine Purdon, Ph.D.
Internal-External Member	Jesse Hoey, Ph.D.

Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Martyn Gabel was the sole author for the General Introduction and the General Discussion, which were written under the supervision of Dr. Tara McAuley and were not written for publication.

This thesis consists in part of three manuscripts written for publication. Exceptions to sole authorship of material are as follows:

Research presented in Study 1:

This research was conducted at the University of Waterloo by Martyn Gabel under the supervision of Dr. Tara McAuley. Martyn Gabel designed the study with the consultation of Dr. Tara McAuley. Data was collected by Martyn Gabel, Meagan Koufas and Bawan Gosal. Martyn Gabel conducted data analyses and drafted the manuscript which Dr. Tara McAuley contributed intellectual input and consulted on data analyses.

Citation: Gabel, M. S., & McAuley, T. (2020). React to act: Negative mood, response inhibition, and the moderating role of emotional reactivity. *Motivation and Emotion*, *44*(6), 862-869.

Research presented in Study 2:

This research was conducted at the University of Waterloo by Martyn Gabel under the supervision of Dr. Tara McAuley. Martyn Gabel designed the study with the consultation of Dr. Tara McAuley. Data was collected by Netri Kalra and Martyn Gabel. Martyn Gabel conducted data analyses and drafted the manuscript which Dr. Tara McAuley contributed intellectual input and consulted on data analyses.

Citation: Gabel, M. S., & McAuley, T. (In preparation). Why might negative mood help or hinder inhibitory performance? An exploration of thinking styles using a Navon induction.

Research presented in Study 3:

This research was conducted at the University of Waterloo by Martyn Gabel under the supervision of Dr. Tara McAuley. Martyn Gabel designed the study with the consultation of Dr. Tara McAuley. Data was collected by Agampreet Kaur, Valeria Navarrete and Martyn Gabel. Martyn Gabel conducted data analyses and drafted the manuscript which Dr. Tara McAuley contributed intellectual input and consulted on data analyses.

Citation: Gabel, M. S., & McAuley, T. (In preparation). The influence of affective and motivational states on response inhibition performance.

As lead author of these three studies, I was responsible for conceptualizing study design and/or data analytic planning, carrying out data analyses, and drafting manuscripts. Dr. Tara McAuley provided guidance and/or input during each step of the research and provided feedback on draft manuscripts.

Abstract

Several theoretical accounts postulate an influence of mood on response inhibition, a central component of executive function (EF) that refers to withholding pre-potent responses that are inappropriate within a particular goal-context. The first of these accounts, cognitive load theory, assumes that all emotional arousal (positive or negative) places demands on EF via task-unrelated thoughts and thus increased emotional experience is more likely to decrease EF performance. The mood-as-information theory suggests that negative mood indicates threat and promotes an analytic thinking style which will improve EF skills, such as response inhibition, that should benefit from a more analytic approach to information processing, whereas positive mood stimulates a heuristic thinking style which will have the converse effect. Finally, motivational accounts suggest that emotional valence (positive vs. negative) is less important than the underlying motivational system that is engaged through the emotional experience. Herein, it is predicted that response inhibition will be bolstered by approach motivation (e.g., anger, curiosity) but hindered by avoidance motivated experiences (e.g., anxiety). Given inconsistent research findings in the literature regarding the interplay of mood and response inhibition, my master’s research examined emotional reactivity as a potential moderator of this relationship. Emotional reactivity is stable trait that denotes the typical rapidity, intensity, and duration of an emotional response. It was predicted that individuals who experience stronger, more frequent, and longer-lasting negative emotions (i.e., those higher in reactivity) would be more accustomed to the experience of a negative mood and thus able to utilize an analytic thinking style to enhance their inhibitory performance without experiencing an associated increase in cognitive load – whereas the opposite would occur for those lower in reactivity (leading to a decrement in inhibitory performance). The interaction of emotional reactivity and

negative affect emerged as a significant predictor of response inhibition in the way that was hypothesized. The current dissertation aimed to replicate and extend these findings. Study 1 was conceptually similar to my master's research but used an experimental design to induce negative and positive mood states (vs. exploring naturally occurring fluctuations in mood). Similar to results from my master's research, participants lower in reactivity performed more poorly on a task of response inhibition with increasing levels of negative mood while those higher in reactivity demonstrated the opposite trend. Additionally, individuals lower in reactivity performed more poorly in the negative mood condition than in the positive mood condition while those higher in reactivity performed comparably across conditions. These findings further support emotional reactivity as a moderator of the mood-inhibition relationship and are consistent with the suggestion that negative mood may promote an analytic thinking style that can be utilized by individuals who are accustomed to unpleasant emotional experiences (i.e., high reactive individuals) but engenders greater cognitive load for those who are not (i.e., low reactive individuals). The affective certainty model, which predicts interference in EF tasks when moods are trait-inconsistent emerged as a model that shared consistency with these results and was compatible with both the mood-as-information and cognitive load theories. Predictions stemming from mood-as-information theory were more directly assessed in Study 2, which manipulated thinking style (analytic vs. heuristic) through a Navon-like induction. In the heuristic condition, based on the finding that people are generally in a positive mood state and that consequently they tend to employ a heuristic thinking style it was predicted that there would be a replication of the interaction from my master's research where negative affect would instill cognitive load for low but not high reactive individuals. Consistent with this prediction, as well as findings from Study 1 and my master's work, increasing negative affect was associated with

better inhibitory performance for individuals higher in reactivity while those lower in reactivity demonstrated the opposite trend. In the analytic condition, it was predicted that focusing on local information would engender an analytic thinking style which would be enhanced by negative affect and override cognitive load instilled by this affective state. Consistent with this prediction, participants' performance improved with increasing levels of negative affect regardless of emotional reactivity. In neither condition, however, was there compelling evidence that the pattern of results could be attributed to the manipulation of thinking style. Finally, Study 3 tested predictions following from motivational accounts of affective influences on EF by inducing emotions (anger, anxiety and boredom) that tap into differing motivational systems (approach vs. avoidance). Contrary to my hypothesis, response inhibition was comparable across conditions. However, when negative arousal was considered in the model, the anxiety and anger conditions diverged such that as negative affect increased in the anxiety condition performance worsened. Conversely, as negative affect increased in the anger condition performance improved. Emotional reactivity was not predictive of performance across conditions. Findings across studies in my doctoral work find consistent support for the affective certainty and cognitive load hypotheses. Study 2 provided partial support for the mood-as-information theory while Study 3 found partial support for the motivational accounts of the EF-mood relationship. Overall, results help to explain inconsistent research findings with the inclusion of an individual differences factor, emotional reactivity, which emerged as a powerful moderator that makes divergent predictions about the effects of affect on response inhibition based on what is affectively normal at an individual level.

Acknowledgments

I am grateful to my supervisor, Dr. Tara McAuley, who has guided me through this process. Thank you for your knowledge and expertise that you have imparted upon me during these formative years. Thank you also to my committee members, Dr. Jonathan Oakman and Dr. Christine Purdon, who provided guidance on the research presented in this dissertation. Your feedback was instrumental in shaping the studies involved in this work.

I would further like to acknowledge my cohort, Beth, Katie, Kevin and other Kevin. You kept me functional throughout this process. I owe my mental health to you all. Finally, to my partner, Emilie, thank you for being there with me through the writing process and guiding me to the finish line. I don’t know if I could have done this without you.

Dedication

To my parents, Debbie and Paul, who taught me to be curious, kind and non-judgmental. You have had a profoundly positive impact on my life. Without your support and guidance, I would not be where I am today.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

Affect

Affect has been defined as a “neurophysiological state consciously accessible as the simplest raw (nonreflective) feelings evident in moods and emotions” (Russell, 2003, p. 148). Mood and emotions both emerge from this common affective basis; however, moods typically involve complex amalgamations of affective experience which are less intense, longer lasting, and lack a well-defined object of reference when compared with emotions (Larsen, 2000; Russell & Barret, 1999).

A four-factor circumplex model of affect was originally postulated by Russell (1980) and included factors of pleasure, excitement, arousal and contentment. This model postulates that both negative and positive affective states vary in their degree of physiological arousal and satisfaction. The factors in this model thus reflect combinations of arousal and pleasure, which are not explicitly teased apart. In subsequent work, Russell and colleagues (Russell, 2003; Russell & Barret, 1999) proposed a model of core affect that includes two bipolar factors of activation (arousal) and pleasure (valence) as well as one vertical dimension that differentiates amongst prototypical emotional episodes (e.g., fear vs. terror). In this model, core affect represents an ever-present dynamic system of emotional experience that is conceptually similar to notions of mood when considered on a longer time-course and supplies individuals with emotional information that may engage different motivational systems that guide goal-oriented behaviour (i.e., avoidance vs. engagement with a stimulus).

Fight or flight are fundamental examples of approach and avoidance behaviours, respectively. Herein, affect is essential in rapid prediction of our environment and engagement in subsequent adaptive behaviour (Barrett & Bar, 2009). As an example, a form that resembles a predator stimulates high arousal, negative valence and avoidance motivation which indicates threat and would likely lead to a flight or freeze response. The repeated pairing of a prediction (e.g., threat from predatory features) with a response (e.g., flight) strengthens the association between the two to create mental shortcuts or heuristics for dealing with various situations. Once the response to the stimulus becomes pre-potent, it requires either a natural extinction of this response (i.e., repetitive exposure to that stimulus without the predicted response) or a more effortful interference of that process via executive function to break it down (Delgado et al., 2008).

Executive Function

Executive function (EF) is an umbrella term for inter-related skills that are used to self-regulate one’s thoughts and behaviours to attain goals (Alvarez & Emory, 2006). Several conceptualizations of EF have been put forth varying in the number, nature, and organization of skills that are identified (Goldstein et al., 2014). One widely accepted model is the unity and diversity framework initially proposed by Miyake and colleagues in 2000 and refined in 2012 (Miyake et al., 2000; Miyake & Friedman, 2012). In this model, EF is conceptualized as hierarchically organized skills in which lower levels support increasingly complex, higher-order behaviours. The most foundational skill is response inhibition (also referred to as ‘common EF’), which entails withholding responses that are pre-potent yet inappropriate within a particular goal-context. Response inhibition as a skill is marked by a balance between speed in responding when it is needed and accuracy in inhibiting a response when appropriate. Not responding when it is required and responding when it is inappropriate can both be detrimental in quickly adapting to novel situations. Evidence for the primacy of response inhibition vis-à-vis other executive skills comes from latent modeling of adult task performance (Miyake et al., 2012) and developmental research identifying it as the first executive skill to emerge and fully mature (Bell & Fox, 1992; Huizinga et al., 2006). Inhibition, in turn, supports two executive skills that are also viewed as core components of EF: working memory (Baddeley & Hitch, 1974), which actively monitors, represents, and updates goal-relevant information, and switching (Monsell, 2003), which involves flexibly shifting attention between tasks or mental sets for the purpose of goal attainment. Response inhibition, working memory, and shifting promote other executive skills, like planning, organization, self-monitoring, and emotion regulation – all of which are necessary for behaving adaptively in the real-world (Harms et al., 2014; Koechlin, 2016; Pugliese et al., 2015).

An important function served by response inhibition is that it allows for a recalibration of heuristics created through punishment or reward reinforcement when a heuristic is inappropriate given the goal-context. Alternatives to these heuristics may be considered via working memory and alternate behaviours that are more adaptive or rewarding can be implemented via switching. In other words, response inhibition is the aspect of EF that signifies conflict between our prediction system and behaviour that would be more situationally appropriate. Thus, while reward and punishment reinforcement via affective systems creates predictive shortcuts, response inhibition involves withholding shortcuts that are inappropriate given the situation.

Executive Function and Affect

Accordingly, we can see how response inhibition and affect might interact to predict adaptive behaviour. Affective systems can be extremely helpful in allowing for quick and efficient processing of information which requires little effort. For example, putting one foot in front of the other on a well-known trail helps move us forward without bombarding us with uncertainty about our next step. If, however, our environment is more uncertain (e.g., novel, dangerous) we may need to inhibit this heuristic response to minimize the potential for harm (Pessoa, 2009). This would call for an inhibition of this heuristic and adoption of a more cautious or analytic approach which is beneficial in the sense that it will aid in reducing harm when it is situationally adaptive to do so. Utilizing the same example, looking at where your foot is going to be placed before putting it down or planning your next couple of steps before taking them on a difficult part of the trail. Through this example, we can see that the interaction of affective (heuristic) and response inhibitory (analytic) processes are helpful for effectively approaching an ever-changing environment. Theoretical perspectives regarding the interplay of affect and EF are summarized below.

Cognitive Load Theory

Cognitive load theory suggests that both positive and negative affect engage working memory (e.g., through emotion regulation), which limits available resources that could be utilized for EF tasks. In other words, any kind of affective experience increases the likelihood that there will be a decrement in the application of executive skills. A review conducted by Mitchell and Phillips (2007) noted that little work had examined the interplay of EF and negative affect at that time. However, their review identified instances in which positive moods had varying affects on EF depending on the executive skill under consideration (e.g., generally positive for creativity, negative for working memory, and mixed for response inhibition). Based on available evidence regarding the association of positive affect and EF, Mitchell and Phillips (2007) concluded that there was insufficient empirical support for cognitive load theory. Although not directly related to EF, Seibert and Ellis (1991) found that task-irrelevant thoughts on a memory recall task were significantly higher in positive and negative mood induction conditions than in a neutral mood condition. Memory recall was also significantly better in the neutral condition than in the positive or negative mood conditions. Finally, they found that the negative relationship between task-irrelevant thoughts and recall performance was linear across all three mood conditions. Taken together, these findings suggest that cognitive load is likely imposed through mediating mechanisms, such as task-irrelevant thoughts, that are amplified through positive and negative arousal. More recent research by Curci and colleagues (2013) has tested this hypothesis of cognitive load instilled through rumination by examining performance on a task of working memory in negative and neutral mood conditions. Working memory performance at post-test was lower and ruminative thoughts were higher in the negative mood condition. Moreover, rumination fully mediated the relationship between negative emotional experience and working memory performance across conditions. As such, it is thought that cognitive load is imposed by affect through a mediating mechanism such as task-irrelevant thoughts or rumination which likely increases with the level of emotional arousal experienced. Therefore, it is thought that positive and negative affect will only instill cognitive load through these mediating mechanisms, but it also stands to reason that at extreme levels of arousal (e.g., terror, elation) both positive and negative affect would interfere with EF. Given that the studies within this dissertation look at natural variations in mood and induced affective states within a lab-setting, we anticipate that cognitive load will only be incurred through task-irrelevant thoughts activated via mood.

Mood-as-Information Theory

In contrast to cognitive load theory, mood-as-information theory suggests that affect has the potential to help or hinder EF pending the nature of both the affective state and executive skill (Schwarz & Clore, 2003). According to this perspective, negative mood indicates the presence of threat and shifts individuals to a more analytic processing style whereas positive mood signifies the absence of threat and induces individuals to a more heuristic processing style. Considerable work has demonstrated that moods influence information processing in the manner suggested by mood-as-information theory. For example, Park and Banaji (2000) demonstrated that individuals in negative mood states were more analytic and individuals in positive moods were more heuristic in how they processed information. Consistent results were reported by Gasper and Clore (2002), who found that participants in a negative mood condition exhibited a strong bias towards processing information analytically. They also found that their neutral mood condition resulted in high positive mood, which led to a heuristic bias towards processing information. This latter finding is consistent with the suggestion that when mood is not actively manipulated, individuals tend to experience more positive than negative affect overall and a tendency for information to be processed more heuristically (Diener & Diener, 1996; Xu et al., 2019). Further support for this view comes from the seminal work of David Navon (1977). Although he did not manipulate mood, his research established that individuals naturally demonstrate a heuristic information processing bias when presented with stimuli that are incongruent at the global and local levels (e.g., a large ‘n’ made up of smaller ‘b’s’).[1] This makes intuitive sense, considering that it would be resource intensive to analyze an object's component parts to deduce what it is. Simply put, it is easier to represent one forest than 100,000 trees.

Similar to mood-as-information theory, Fredrickson’s (2001) broaden-and-build hypothesis suggests that positive mood leads to an expansion of cognitive scope because it denotes the absence of threat and promotes more heuristic processing (i.e., less of a need to be cautious) whereas negative mood indicates the presence of threat and leads to a more analytic thinking style that actively scans the environment for risks (i.e., more of a need to be cautious).

---

[1] Throughout this dissertation heuristic processing will be equated to identifying information at a global level while analytic processing will be synonymous to local level processing.

Although these theoretical perspectives share some conceptual overlap, mood-as-information theory views negative mood as infrequent and uncomfortable – requiring some form of active regulation to return to a state of comfort (Schwarz & Clore, 1983; 2003). Consistent with cognitive load theory, Schwarz and Clore (2003) expected that since negative moods are infrequent for most, they would need to explain or regulate them which would lead to interference in analytic thinking via emotion regulation (e.g., cognitive reappraisal). However, negative mood was associated with analytic thinking in several experiments (Mackie et al., 1992; Park & Banaji, 2000; Schwarz et al., 1991). While these studies draw a connection between analytic processing and negative affect, it is unknown whether active emotion regulation interferes with this analytic processing during EF tasks.

Affective Certainty Theory

Research by Tamir and colleagues (Tamir & Robinson, 2004; Tamir et al., 2002) has suggested incorporating individual differences in state and trait affect into the mood-as-information theory. Trait affect refers to an individual's general experience of affect and tends to be more stable over time (e.g., neuroticism). Conversely, state affect is a transient experience of affect (e.g., anxiety) expressed in a given situation (Tamir & Robinson, 2004). Their affective certainty model found that personality traits such as extraversion and neuroticism, which are related to increased trait positive and negative affect respectively, were associated with improved performance on sorting tasks when state and trait affect were consistent. Tamir et al. (2002) demonstrated that extraverts perform better on a decision-making task when in a positive mood while introverts perform better when in a negative mood. Similarly, Tamir and Robinson (2004) found that individuals high in neuroticism performed better on a categorization task when in a negative mood while those low in neuroticism performed worse. The affective certainty model proposes that trait-consistent mood states are indicative of predictability in our environment and lead to effective functioning within it (Tamir & Robinson, 2004; Tamir et al., 2002).

Although the affective certainty model helps to explain the pattern of results observed in these two studies, the mechanism explaining this pattern of results remains unspecified. It is plausible that affective uncertainty may motivate individuals to regulate trait-inconsistent emotions, similar to what was posited by Schwarz and Clore (2003), which may introduce cognitive load in the form of task-irrelevant thoughts that could involve rumination to up-regulate negative emotions or cognitive reappraisal to down-regulate negative emotions. Thus, although it might be intuitive to think that all individuals want to be in a more pleasant mood state, negative mood states that are trait-consistent provide predictability and comfort and might motivate individuals to maintain a negative mood. This motivational theory of emotion regulation has also been supported through research by Tamir and colleagues (Tamir, 2005; Tamir et al., 2017; Tamir et al., 2020).

Motivational and Arousal Accounts

Mitchell and Phillips' (2007) final hypothesis is based upon Isen's (1999) work which states that mild positive mood states will facilitate performance on tasks of creativity and will have no effect on tasks that require systematic processing such as tasks of response inhibition or working memory. The idea that specifically mild positive mood states are beneficial for EF tasks that require broadened cognitive scope, suggests a special role for mood-related arousal on task performance. Arousal, or activation, is featured in prominent models of affect (e.g., Russell, 2003). It is possible that differences in level of emotional arousal may be ideal for certain executive skills, with too much or too little causing interference. Indeed, research has supported this claim with both high negative and positive arousal leading to decreases in response inhibitory performance (Verbruggen & de Houwer, 2007). This effect has been supported through research by Pessoa and colleagues (Pessoa et al., 2012) especially with regards to high arousal negative affect.

Other more recent work has further explored different discrete emotional states and how their underlying differences in motivational systems interact with attention (Corr, 2004; Gable et al., 2015; Harmon-Jones, 2003; Harmon-Jones et al., 2011; Gasper & Zawadzki, 2013; Shields et al., 2016). Reinforcement sensitivity theory (RST; Gray, 1970; Gray & McNaughton, 2000) identifies three motivational systems of emotion: the behavioural activation system (BAS), behavioural inhibition system (BIS) and the fight/flight/freeze system (FFFS). The FFFS refers to high arousal emotional states such as fear or panic which result in a fight, flight or freeze response in pursuit of avoidance of aversive stimuli (Gray & McNaughton, 2000). The BAS is hypothesized to be related to emotions that provide positive and negative reinforcement and are associated with rewarding stimuli (Gray, 1970). This system embodies approach motivation and primarily includes positive emotions but has also been related to negative emotions such as anger (Harmon-Jones, 2003). Conversely, the BIS is hypothesized to be related to resolving goal conflict (e.g., approaching threat in pursuit of a goal) and is primarily associated with the experience of anxiety. Activation of this system engages problem solving and risk assessment which can increase the likelihood of experiencing worry and rumination (Corr, 2004). Interestingly, unlike the aforementioned theoretical accounts, the RST suggests that two negatively valenced emotions, anger and anxiety, might influence attentional processes in divergent ways through activation of the BAS and BIS respectively. It is therefore possible that a more nuanced understanding of how affective experiences influence response inhibition may be obtained by considering the interplay of motivational systems that are triggered by affective states.

Indeed, recent research has demonstrated that anger facilitates, whereas anxiety hinders, EF performance (Shields et al., 2016). Furthermore, research by Roskes and colleagues (Roskes et al., 2013) suggests that avoidance motivated arousal (i.e., BIS/FFFS) is more cognitively and physiologically demanding than approach motivated arousal (i.e., BAS) which may lend some credence to the cognitive load hypothesis for avoidance motivated emotional states. In contrast, approach-oriented states may provide an analytic thinking style whilst also promoting engagement with a task that is not impaired through cognitive load. Herein, it is important to note that the study by Gable and colleagues (Gable et al., 2015) found that positive emotions high in engagement (e.g., curious) also promoted a more analytic focus through engagement with a particular stimulus. Conversely, low arousal negative states such as sadness have also been shown to broaden cognitive scope (Gable & Harmon-Jones, 2010b). Consistent with this, research by Isen (1999) and Fredrickson (2001) supports the idea that low arousal positive mood states broaden cognitive scope as well.

Taken together, research examining motivational and arousal systems adds to mood-as-information theory by suggesting these components of emotional information lead to differences in cognitive scope that will focus an individuals attention on avoidance or approach depending on the discrete emotional state. It is suggested that approach motivation will be beneficial to response inhibition, although there is only one known study that has looked at motivation and EF specifically (Shields et al., 2016). Moreover, no known research has supported mood-as-information theory and a connection with response inhibition. There has been some support in the literature that trait-inconsistent emotions may instill cognitive load through affective uncertainty (Tamir & Robinson, 2004; Tamir et al., 2002) or emotion regulation (e.g., rumination; Curci et al., 2013) but clear support for any of the aforementioned theories has not been observed. The studies presented in this dissertation aim to test these theoretical models by looking at individual differences in the experience of affect.

Individual Differences in Affective Experience: Emotional Reactivity

Affect and response inhibition have not consistently demonstrated a clear relationship in the literature, which is perhaps due to the simplification of affect to a single dimension (valence) without consideration of other dimensions (motivation and information processing); however, another potentially relevant factor that has been often overlooked is individual differences in the experience of affect. As mentioned, research by Tamir and colleagues (Tamir & Robinson, 2004; Tamir et al., 2002) has looked at personality components such as neuroticism and extraversion and discovered interactive effects on tasks of decision making where trait-consistent moods led to increases in performance. An individual differences factor similar to neuroticism is emotional reactivity. Emotional reactivity and neuroticism are similar in that they are related to increased negative affect but divergent in that emotional reactivity is not related to positive affect while neuroticism is associated with decreased positive affect (Nock et al., 2008; Thake & Zelenski, 2013). This is an important conceptual difference as it assumes that negative affect is trait-consistent for those higher in emotional reactivity and trait-inconsistent for those lower in emotional reactivity but does not specify that positive affect would be trait inconsistent based on emotional reactivity. Data from an unpublished manuscript by Gabel and McNeil (in preparation) supports that emotional reactivity and neuroticism are separate but related constructs with a correlation of about .65.

Emotional reactivity is a primary individual differences factor that is related to both arousal and valence of emotional experience. Emotional reactivity is defined as a stable individual differences trait that reflects the rapidity, intensity, and duration of negative affective and arousal responses (Howland et al., 2017; Nock et al., 2008). Individual differences in emotional reactivity are evident in the first year of life, such that infants will respond differently to the same stimulus based on how reactive they are – a finding that persists into the adult years (Diener et al., 1985; Skinner & Zimmer-Gembeck, 2007; Silvers et al., 2012). Across development, emotional reactivity has been linked to factors that increase risk for psychopathology, including neuroticism, negative mood, maladaptive regulation of mood, and insecure attachment (Thake & Zelenski, 2013; Wei et al., 2005). It is important to note that although emotional reactivity has been related to increased risk for psychopathology, it is examined within this dissertation within an undergraduate population and results might not generalize to a clinical population.

My Masters research looked into emotional reactivity as a moderator of the association between naturally occurring variations in mood and performance on tasks of response inhibition and working memory (Gabel & McAuley, 2018). Emotional reactivity and positive and negative affect were measured via self-report while response inhibition and working memory were measured with cognitive tasks. These tasks included letter-number sequencing, operation span and reading span for working memory and the flanker, spatial compatibility and stop signal tasks for response inhibition. Working memory and response inhibition tasks were formed into a structural model and modelled as latent constructs of working memory and inhibition. Consistent with previous research, mood was largely positive with approximately 75% of individuals experiencing more positive than negative emotion. Herein, we found that increasing emotional reactivity was significantly correlated with higher levels of negative (but not positive) affect in our sample. We also found that emotional reactivity moderated the association between negative affect and latent variables of response inhibition and working memory performance, such that individuals higher in reactivity performed better as levels of negative affect increased whereas individuals lower in reactivity showed the converse pattern. This pattern is consistent with the affective certainty model (Tamir & Robinson, 2004; Tamir et al., 2002) such that individuals higher in reactivity may have performed better than individuals lower in reactivity with increasing levels of negative affect because for them these mood states are affectively ‘normal’. For individuals lower in reactivity, these states are novel or trait-inconsistent and require extra processing (e.g., emotion regulation) similar to what would be predicted by the affective certainty, cognitive load and mood-as-information hypotheses (Schwarz & Clore, 2003). In the context of our study, an implication of the foregoing is that negative mood may have placed lesser cognitive demands as reactivity increased and thus higher reactive individuals might be better able to utilize negative arousal to engage in an analytic thinking style to perform the task at hand. Importantly, despite experiencing more frequent and long-lasting negative moods, high reactive individuals do not differ in their experience of positive mood and it may be that negative arousal experienced during both negative and positive moods is not trait-inconsistent to the point of interfering with response inhibitory or working memory tasks.

The current thesis aims to expand upon this work utilizing emotional reactivity as a moderator of affect in examining the relationship between affect and response inhibition. The following studies expand upon my Masters research to include active manipulation of mood states (i.e., positive and negative) and bridge gaps in the literature by directly examining information processing styles (i.e., analytic and heuristic) as well as motivational factors (i.e., approach and avoidance). Chapter 2 explores the relationship between response inhibition and positive and negative valence through an active manipulation of these mood states while examining how emotional reactivity affects this relationship. Chapter 3 builds upon this by assessing how heuristic and analytic information processing styles affect response inhibition while controlling for natural variations in positive and negative affect and utilizing emotional reactivity as a moderator. Finally, Chapter 4 considers how variation in the underlying motivational systems of anger (high arousal approach-motivated), anxiety (high arousal avoidance-motivated) and boredom (low arousal approach-motivated) predict response inhibition while controlling for individual differences in emotional valence and emotional reactivity. These chapters contribute to the literature relating response inhibition to affect by integrating broader theoretical perspectives which include information processing and motivational systems engendered by divergent emotional states while incorporating an understanding of individual differences in emotional reactivity. Results in the following chapters generally support a more nuanced relationship between affect and response inhibition which suggests that as emotional reactivity increases, negative affect leads to less interference during the Stop Signal task which is in line with the affective certainty model. The aforementioned relationship of emotional reactivity, negative affect and response inhibition changes when information processing is induced to be more analytical, in line with the mood-as-information theory, or underlying motivation is approach oriented (e.g., anger) such that all individuals seem to benefit from negative affect under these circumstances. The final chapter provides a more detailed summary of these findings, discussion of limitations and potential future directions to explore.

Chapter 2: Emotional reactivity moderates the association between negative mood and response inhibition in a mood induction paradigm[2]

2.1 Introduction

Conscious control of goal-directed behaviour under conditions of strong affective experience can have serious repercussions in the real world. Military leaders must make calculated decisions involving the safety of their soldiers, first responders need to act effectively in emergency situations, and journalists must provide accurate reporting of events under formidable time constraints. Even comparatively mundane acts, like deciding what to wear on a first date or what food to prepare for a picky child, often entail at least some affective load.

Executive functions (EF) refer to cognitive control mechanisms that are required for identifying, working toward, and accomplishing goals (Jurado & Rosselli, 2007). Numerous conceptualizations of EF have been offered, spanning neurobiological, cognitive/behavioural, and computational levels of analysis (Banich, 2009). Whilst myriad executive skills have been identified, keeping goal-relevant information in mind (i.e., working memory; Baddeley, 1992), flexibly switching between task-sets (Monsell, 2003), and withholding pre-potent yet goal-incongruent actions (i.e., response inhibition; Nigg, 2000) are widely viewed as central to the EF construct (e.g., Miyake et al., 2000; Miyake & Friedman, 2012).

Lived experience suggests that EF is subject to affective influences like mood; however, different theoretical accounts give rise to varying predictions about the influence of mood states on specific executive skills. Cognitive load theory posits that all moods impose demands on cognitive resources, leading to the prediction that any mood state will interfere with EF-task

---

[2] A version of this chapter is published as Gabel, M. S., & McAuley, T. (2020). React to act: Negative mood, response inhibition, and the moderating role of emotional reactivity. Motivation and Emotion, 1-8. It is reproduced here with permission.

performance (e.g., Seibert & Ellis, 1991). In contrast, mood-as-information theory posits that moods may help or hinder EF-task performance depending on the cognitive consequences that a specific mood state engenders. In their cognitive cuing account, for example, Schwarz and Clore (2003) suggest that negative moods signify threat and engender an analytic processing style that is beneficial for tasks requiring close attention to detail. Conversely, positive moods signify safety and promote a heuristic processing style that is advantageous for tasks involving creativity, fluency, and cognitive flexibility. Similar predictions follow from Fredrickson's (2001) broaden-and-build account, which posits a link between different mood states and thought-action repertoires. Here, it is suggested that negative moods encourage decisive responses to immediate threat, whereas positive moods facilitate engagement in exploratory tasks that build adaptive behaviour for future use. A review conducted by Mitchell & Phillips (2007) concluded that there was not compelling support for these theoretical perspectives based on available evidence at that time. Although positive moods were consistently shown to bolster performance on tasks requiring flexible and/or expansive thinking, few studies had explored the interplay of negative moods and task performance and reported findings were mixed.

Considerable work has explored affective influences on cognition, most notably memory (e.g., Murray et al., 2013, Forgas & Koch, 2013). To extend this body of work to EF, our previous study examined the interplay between mood and performance on tasks of response inhibition and working memory (Gabel & McAuley, 2018). Given heterogeneity of extant research findings, we were particularly keen to explore whether these associations might be moderated by emotional reactivity – a stable individual differences trait that reflects the rapidity, intensity, and duration of negative, but not positive, affective responses (Howland et al., 2017; Nock et al., 2008). We found that task performance was degraded with increasing negative mood for low-reactive individuals whereas high-reactive individuals tended to show the converse pattern in a sample that included undergraduate students. These results were obtained when response inhibition and working memory were modeled as latent constructs and were replicated on all three of the response inhibition tasks that were individually examined. Given our pattern of findings, we speculated that high-reactive individuals may have performed better than low-reactive individuals when in a negative mood state because for them these states are affectively ‘normal’. Consistent with this speculation, we found that increasing emotional reactivity was significantly correlated with higher level of negative (but not positive) affect in our sample. Likewise, other work also has reported that emotional reactivity is associated with more frequent and long-lasting negative moods (e.g., Compas et al., 2004; Nock et al., 2008). In the context of our study, an implication of the foregoing is that negative mood may have placed lesser cognitive demands on high- compared with low-reactive individuals and so they were able to invest more of their attentional resources into performing the tasks at hand. This explanation suggests that an integration of cognitive load and mood-as-information theories may yield a more nuanced and accurate understanding of affective influences on EF than either perspective considered in isolation.

In our previous study, EF task performance was examined in relation to naturally occurring variations in negative and positive mood in a cross-sectional research design. Whilst this approach enabled us to capitalize on individual differences in the mood states that students brought into the lab, it tempered our conclusions regarding the potential for mood to directly impact EF. To address this limitation and replicate our prior findings, we present here a conceptually similar follow-up study that uses an experimental mood manipulation to induce positive or negative mood prior to administration of an EF task. We selected the Stop Signal task because it is a well-established and psychometrically sound measure of response inhibition that we used in our previous study that has also been used in other investigations of mood-EF associations (Kalanthroff et al., 2013; Pessoa et al., 2012; Verbruggen, & De Houwer, 2007). Integrating predictions from both cognitive load and mood-as-information theories coupled with results of our previous study, we hypothesized that induction of negative mood would hinder performance on an inhibitory task (per cognitive load theory) except in highly-reactive individuals, for whom negative mood may be more affectively normal and thus less cognitively depleting. As such, we expected that highly-reactive individuals would benefit from the informational significance of a change in negative affect by increasing their attention to the inhibitory task (per mood-as-information theory). Of note, both theories predict a decrement in inhibitory performance following induction of positive mood. However, given other work demonstrating no effect of positive mood on response inhibition (Martin & Kerns, 2011), coupled with null results from our prior study, we expected that positive mood would have no bearing on inhibitory performance.

2.2 Method

Participants

Participants were recruited through a departmental pool of students enrolled in psychology courses at the University of Waterloo. Our previous study of undergraduates found a significant interaction between emotional reactivity and negative mood on inhibitory performance controlling for positive mood ($\Delta R^2 = .13$; Gabel & McAuley, 2018). Using the software program G*Power (Faul et al., 2009), we calculated the sample size required for an R^2 increase with the following parameters: $f = .15$ (corresponding to $R^2 = .13$), $\alpha = .05$ and $\beta =. 80$. This analysis indicated that 55 participants were required, consistent with the a priori power analysis of Shields et al., (2016) who conducted a conceptually similar study with a total of 150 participants across 3 groups. In our study, we doubled our target sample size due to the inclusion of both a negative and positive mood induction condition. In total, 121 undergraduates completed a 30-minute experimental procedure for course credit (M_{age} = 19.97 years, *SD* = 2.29 years, 70% female, 42% Caucasian 30% Asian, 7% South Asian, 21% Other).

Measures

Visual Analog Ratings. Separate visual analogue scales were used to assess positive and negative feelings experienced by participants in the moment via mouse-click. Instructions asked participants to, ‘rate how you are currently experiencing positive and negative emotions ranging from 0-100, where 0 corresponds to no positive or negative emotion at all and 100 represents very strong positive or negative emotion.’ Ratings were obtained in both the negative and positive mood conditions at baseline, post-induction and post-task. These ratings were used as a manipulation check to see if appropriate affect increased or decreased from baseline to post-induction and to see if this effect remained until completion of the Stop Signal task.

Stop Signal Task (Logan, Cowan, & Davis, 1984). Participants made a speeded choice keypress response to a centrally presented stimulus (pink or yellow star) except when the stimulus was followed by an auditory signal that cued them to cancel their response. Timing of the stop signal, referred to as the stop signal delay (SSD), was initially set to 250 ms post-stimulus onset for all participants. The SSD was subsequently adjusted based on each participant’s response on the preceding stop trial: SSD was increased by 50 ms following a failure to inhibit and was decreased by 50 ms following a successful inhibit. Because timing of the SSD influences the likelihood of inhibitory success, having this dynamic tracking algorithm calibrated to each individual participant ensured that they were able to successfully inhibit their responses on approximately half of stop trials (see also Band et al., 2003). The task was presented in four blocks that each included 8 stop trials and 24 go trials. Stop signal reaction time (SSRT), calculated in ms as the mean SSD subtracted from the mean reaction time of correct responses on go trials, is a well-validated metric of inhibitory ability (*M* = 298.42, *SD* = 64.16, 95% CI [286.24 – 310.60], Cronbach's α = .93).

Emotion Reactivity Scale (ERS; Nock et al., 2008). Participants rated their reactions to 21 items using a 5-point Likert scale ranging from *not at all like me* (0) to *completely like me* (4). Items reflected emotional sensitivity (e.g., "my feelings get hurt easily"), emotional persistence (e.g., "when something happens that upsets me, it's all I can think about for a long time"), and emotional arousal/intensity (e.g., "when I experience emotions I feel them very strongly/intensely"), which were summed to create a total score (*M* = 33.30, *SD* = 18.57, 95% CI [29.86 – 36.74], Cronbach's α = .95).

Demographic Questionnaire. Included were questions regarding age, sex, ethnicity, and medical history.

Procedure

All participants completed the experiment in the same fixed order. Participants were first asked to complete visual analogue scales reflecting the extent of their positive and negative feelings at that moment. Using a variant of the mood induction procedure described by Eich and colleagues (Eich et al., 2007), participants were then randomly assigned to a positive (n = 61) or negative (n = 60) mood induction condition in which they were asked to think about an event that was upsetting (e.g., failure on a test) or happy (e.g., visiting with a close friend) whilst listening to mood-congruent music (Mars, the Bringer of War and Venus, the Bringer of Peace, respectively). These pieces have been utilized previously to elicit positive and negative emotions

(Quigley et al., 2012). The duration of the mood induction procedure was 5 minutes for participants in both conditions. Afterward, participants provided visual analogue ratings, completed the Stop Signal task, provided visual analogue ratings again, and then completed the Emotion Reactivity Scale and Demographic Questionnaire.

2.3 Results

Data were missing for ten participants on the Stop Signal task and from four participants on the ERS. Missing data were imputed using AMOS 25 based on 40 iterations of 30 000 observations of the regression model with a maximum autocorrelation of 0.1 and a tuning parameter of 0.7. All analyses were then completed with SPSS version 25. Pooled parameters were used to estimate the true effects of the predictive model (Graham, 2009). Results were unchanged when analyses were undertaken using only participants with complete data.

Descriptive statistics for affect ratings in each condition and time point are presented in Table 2.1. Effectiveness of the mood induction was evaluated using a 2x3 mixed factors ANOVA, with time (baseline, post-induction, post-task) and mood rating (positive, negative) as repeated-measures factors and condition (negative, positive) as a between-group factor. The three-way interaction was significant [$F(2, 176) = 53.56$, $p <$ 001]. To verify that there was an effect attributable to the mood manipulation that was present after the induction and evident after completion of the Stop Signal task, we evaluated group differences in positive and negative ratings at each time point. There were no significant group differences in affective ratings at baseline (*F*s <1). However, ratings of positive mood were significantly higher in the positive vs. negative induction condition both post-induction [$F(1, 104) = 56.59$, $p < .001$] and post-task [$F(1, 103) = 25.65$, $p < .001$]. Likewise, ratings of negative mood were significantly higher in the negative vs. positive induction condition both post-induction [$F(1, 97) = 52.43$, $p < .001$] and post-task [$F(1, 97) = 24.87$, $p < .001$]. Correlational analyses further demonstrated that the change in negative and positive affect ratings (i.e., post induction less baseline) was not significantly correlated with emotional reactivity in either mood induction condition (*p*'s > .68). Results indicate that our procedure elicited the intended mood state and that the degree to which this mood state was induced did not differ based on level of emotional reactivity (Figure 2.1). Interestingly, post-induction and post-task negative affect were not correlated with emotional reactivity in the negative mood condition ($r = .07$, $p = .58$ and $r = .04$, $p = .76$ respectively).

Figure 2.1.

Mean intensity ratings for positive and negative mood obtained at three time-points in each mood induction condition. Error bars reflect +/- 2 standard errors of the mean.

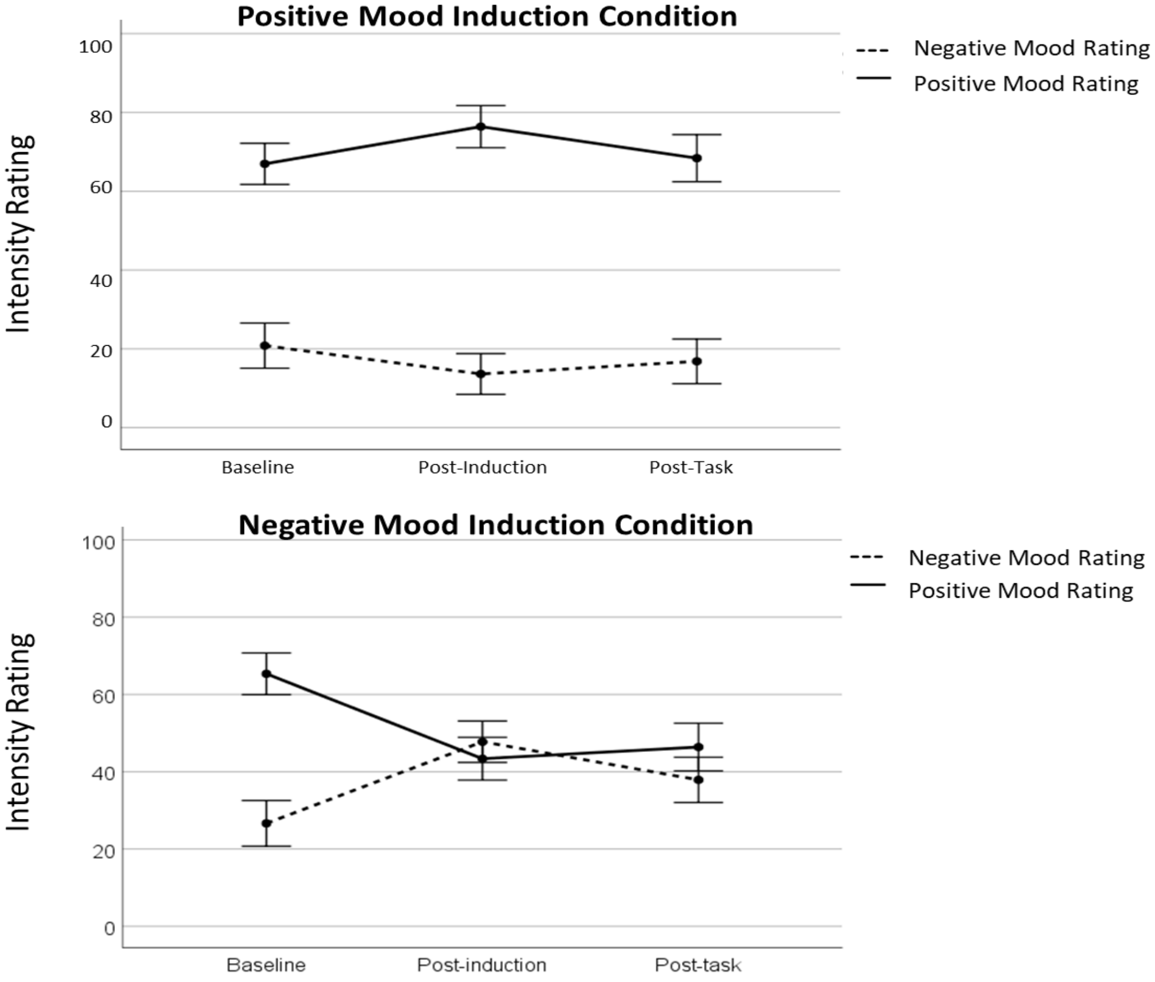


Table 2.1.

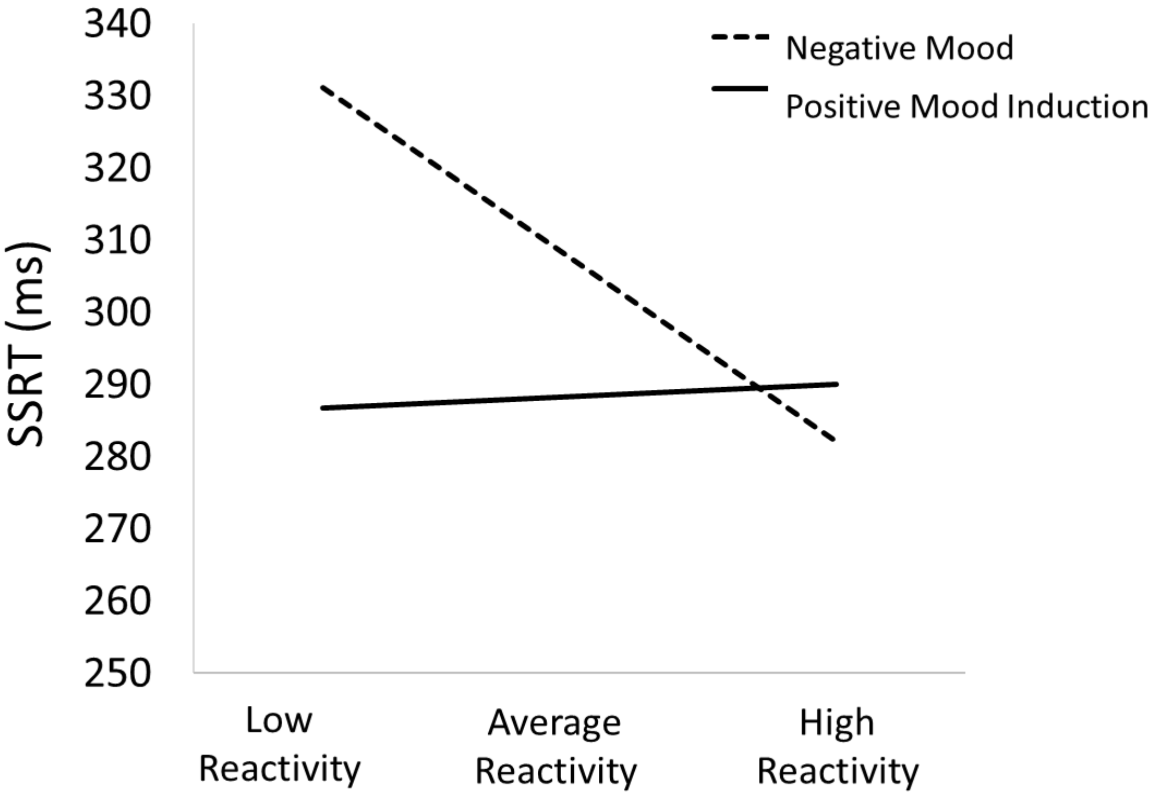
Means, standard deviations, and 95% confidence intervals for positive and negative affect ratings in mood induction conditions at each time point.

Condition	Time	Affect	Mean	SD	95% CI
Negative	Baseline	Positive	65.53	19.80	60.61, 70.45
		Negative	26.43	22.15	21.19, 31.68
	Post-Induction	Positive	45.62	19.10	40.56, 50.69
		Negative	45.17	20.66	40.22, 50.13
	Post-Task	Positive	47.81	21.58	42.34, 53.28
		Negative	36.04	20.45	30.85, 41.22
Positive	Baseline	Positive	67.48	16.00	62.41, 72.55
		Negative	20.38	15.56	14.98, 25.78
	Post-Induction	Positive	77.26	18.04	72.04, 82.48
		Negative	13.02	15.11	7.92, 18.12
	Post-Task	Positive	69.16	18.34	63.53, 74.79
		Negative	16.20	17.40	10.86, 21.53

Multiple linear regression was used to model SSRT as a function of mood induction condition, emotional reactivity, and their interaction. Age and gender were not significantly associated with SSRT (*p*'s > .321) and so were not entered as co-variates. The overall model was statistically significant, $R^2 = .09$, $F(3, 117) = 3.83$, $p = .01$, 95% CI [.10 – .49]. Neither emotional reactivity ($B = -.62$, $SE = .35$, $p = .08$, 95% CI [-1.32 – .08]) nor mood induction condition ($B = -15.97$, $SE = 11.92$, $p = .18$, 95% CI [-39.81 – 7.87]) were significant predictors of SSRT alone.

However, the interaction term emerged as a significant predictor of SSRT, $\Delta R^2 = .043$, $F(1, 117) = 4.93$, $B = 1.43$, $SE = .70$, $p = .04$, 95% CI [.06 – 2.80]. Using pooled data from the multiple imputation, simple slopes for the regression of emotional reactivity on Stop Signal performance were tested in the mood induction conditions using the PROCESS macro for SPSS (Hayes, 2017). As shown in Figure 2.2, performance did not vary as a function of reactivity level within the positive condition ($B = .10$, $SE = .45$, $p = .83$, 95% CI [-0.80 – .90]). Within the negative condition, however, performance improved with increasing levels of reactivity ($B = 1.35$, $SE = .55$, $p = .02$, 95% CI [0.25 – 2.45]).

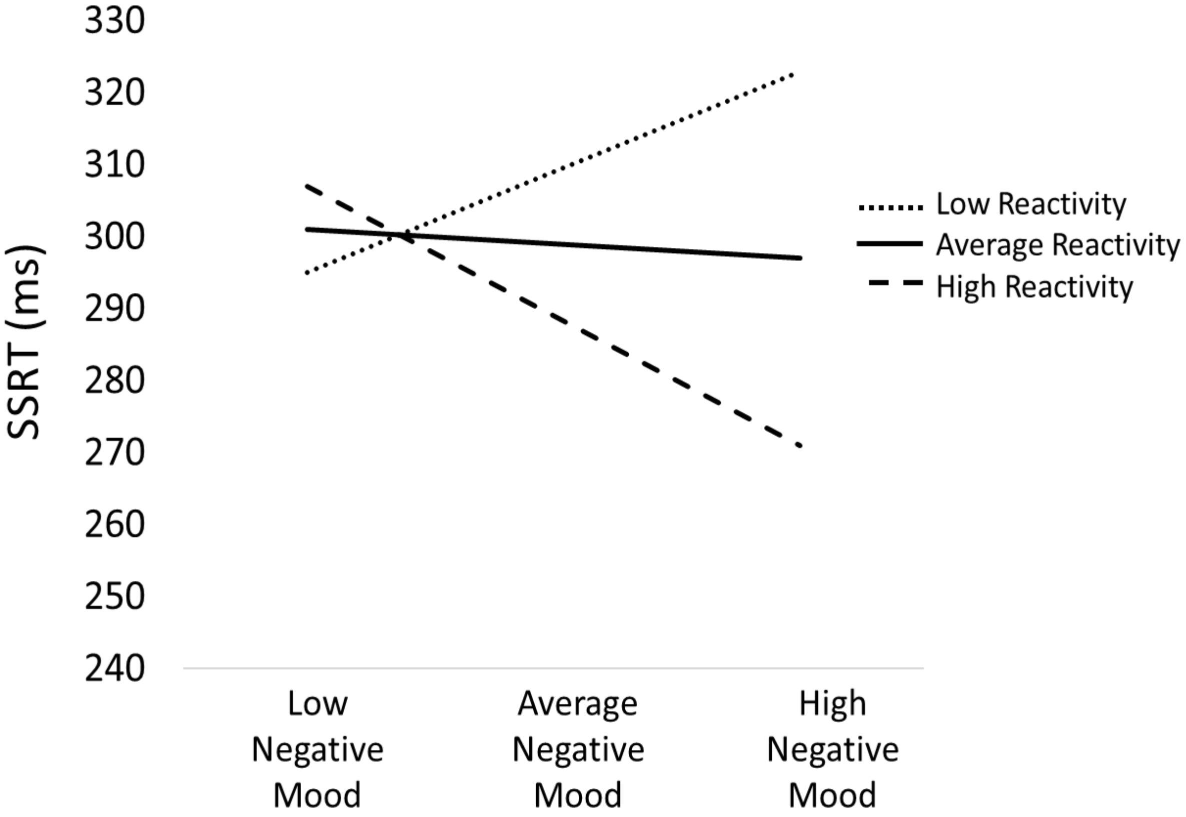
Figure 2.2. *Simple slopes demonstrating the regression of emotional reactivity on inhibitory performance in each mood induction condition.*



Our final analysis examined whether the interaction of emotional reactivity with individual differences in post-induction negative mood predicted inhibitory performance with post-induction positive mood treated as a covariate. Using the PROCESS (Hayes, 2017), the regression of SSRT on negative affect was examined in those with average, high (+1 SD of the mean), and low (-1 SD of the mean) levels of emotional reactivity. As shown in Figure 2.3, this analysis demonstrated that highly reactive individuals had significantly faster SSRTs with increasing negative mood (*B* = -.43, *SE* = .21, *p* = .04, 95% CI [-.86 - .02]) and, individuals low in reactivity showed the converse pattern (*B* = .34, *SE* = .24, *p* = .15, 95% CI [-.13 – .81]). For individuals average in reactivity mood was unrelated to task performance (*B* = -.05, *SE* = .17, *p* = .77, 95% CI [-.38 - -.28]).

Figure 2.3.

Simple slopes demonstrating the regression of individual differences in negative affect on inhibitory performance as a function of emotional reactivity, with positive affect controlled.



2.4 Discussion

Our study joins a body of work aimed at further elucidating the nature of mood-cognition associations through the incorporation of theoretically informed moderators. Individual differences factors such as personality have previously demonstrated a moderating effect of affect on some aspects of cognition (Stafford et al., 2010; Tamir & Robinson, 2004, Tamir et al., 2002). In one study, for example, individuals high in extraversion demonstrated superior performance on a task of creativity following induction of positive mood. There also was a main effect of positive mood on a free recall task, but no main effect or interaction of positive mood and extraversion on inhibitory performance (Stafford et al., 2010). In another study, individuals high in neuroticism were faster to categorize words when naturally experiencing higher levels of negative mood – a finding that was replicated when negative mood was experimentally induced (Tamir & Robinson, 2004). Our findings in the current study were highly consistent with the findings of Tamir and Robinson (2004). The affective certainty model suggested by Tamir and colleagues (Tamir & Robinson, 2004; Tamir et al., 2002) builds on cognitive load theory by proposing that trait-inconsistent moods, such as an individual high in neuroticism who is feeling positive, will lead to more interference then when moods are consistent with how individuals typically feel. The authors' explanation of their results suggested that state-trait incongruent moods build uncertainty or ambiguity which may then interfere with decision making. This is a plausible explanation as to why we might have observed the pattern of results in the current study within the negative mood condition and also helps us to understand the interaction in Gabel and McAuley (2018). Within the current study, however, it is inconsistent with Tamir and Robinson (2004) in that there was no evidence of high reactive individuals performing worse in the positive mood condition.

Given that emotional reactivity is not related to positive mood while positive mood is negative related to neuroticism, it is likely that positive moods are not state incongruent for individuals higher in reactivity. In both Gabel and McAuley (2018) and the current study, there is no correlation between emotional reactivity and positive affect. It is interesting to note that higher levels of extraversion and neuroticism are frequently associated with stronger responses to positive and negative mood inductions, respectively (e.g., Larsen & Ketelaar, 1991). We would expect emotional reactivity to be related to increased change in negative affect through a negative mood induction given it is thought to be related to increased sensitivity to and intensity of negative emotions. In our study, however, post-induction changes in mood were not associated with level of emotional reactivity. In our sample, although change in negative affect was unrelated to emotional reactivity, the pattern of results predicted response inhibition performance in a way that was consistent with Gabel and McAuely (2018). It may be the case that emotionally reactive individuals do not have more intense emotional reactions to mood inductions in a lab setting. This has been supported in the literature (Boyes et al., 2020) such that emotionally reactive individuals respond similarly to non-reactive individuals to negative mood induction procedures, but that negative mood caused by mood inductions is more persistent for these reactive individuals. Our predictions as to why emotional reactivity might be beneficial (i.e., affective certainty) relates more to emotional persistence than emotional intensity and thus we do not view this null finding as particularly troubling.

This study, a conceptual follow-up to Gabel & McAuley (2018), provides a more rigorous examination of the interplay between emotional reactivity with mood on EF by using an experimental research design. Our first analysis demonstrated that inhibitory performance was worse amongst individuals lower in reactivity in the negative vs. positive mood induction condition. For them, being randomized to the negative mood induction resulted in a clear performance decrement that was not observed for individuals higher in reactivity. Indeed, whereas the SSRTs of individuals lower in reactivity were slowed by induction of negative mood those of individuals higher in reactivity were clearly buffered from this deleterious effect (Figure 2.2). Our second analysis examined individual differences in post-induction negative mood and further demonstrated that individuals higher in reactivity had significantly faster SSRTs as negative mood increased. For them, inhibitory performance appeared to benefit from increases in negative mood when examined continuously across conditions (Figure 2.3). These findings are consistent with those of our initial study and with the affective certainty model but are demonstrated here with an experimental mood induction procedure, thereby increasing our confidence that negative mood influenced inhibitory task performance and not vice versa.

A question that follows from our work is why emotional reactivity moderated the influence of negative mood on inhibitory performance. While the facilitative effect observed in individuals higher in reactivity is consistent with the affective certainty model (Tamir & Robinson, 2004; Tamir et al., 2002), it is not in opposition to the mood-as-information theory, which suggests that negative moods instill a more analytic mindset that is helpful for performing some kinds of cognitive tasks (e.g., Schwarz and Clore, 2003). At the same time, the performance decrement observed among individuals lower in reactivity, which is also consistent with the affective certainty model, is not necessarily mutually exclusive with the mood-as-information theory. Trait-inconsistent mood states might engender substantial cognitive load (e.g., task-irrelevant thoughts, active emotion regulation) that interferes with an analytic thinking style improving task performance (see Seibert & Ellis, 1991). Future research might actively manipulate thinking style (analytic vs. heuristic) to better understand how it relates to response inhibition performance.

The forgoing suggests that the cognitive sequela of negative moods vary with individual differences in what is affectively normal. This has been demonstrated with emotional reactivity (Gabel & McAuley, 2018), as well as with related constructs such as neuroticism (Tamir & Robinson, 2004) and extraversion (Tamir et al., 2002). In the case of the current study, it may be that highly reactive individuals have developed specific attentional strategies for dealing with threat that coincide with task performance. For example, an avoidant strategy (e.g., distraction, expressive suppression) could be beneficial for task performance by preventing engagement with regulatory strategies that are known to interfere with executive skills – an example of which is rumination (Curci et al., 2012; Koster et al., 2013). Conversely, low-reactive individuals may be less likely to have developed specific strategies when confronted with threat, thereby demonstrating more attentional ambivalence when threat arises during performance of a task. Interestingly, a study by Nelson and colleagues (2015) presented participants with pairs of negative and neutral images and found that individuals who experienced conflict about where to direct their attention - expressing high motivation to both monitor and avoid the disturbing pictures – actually demonstrated the greatest vigilance toward threat. One can readily imagine how this attentional bias would be detrimental to task performance and interfere with the ability to effectively utilize executive skills.

Considering our findings, it is worth noting that heightened emotional reactivity is a risk factor for depression starting as early as adolescence (Charbonneau et al., 2009; Pine et al., 2001). Further, both current and remitted depression have been associated with broad cognitive deficits, including deficits in attention and related executive skills (Mac Giollabhui et al., 2020; Rock et al., 2014; Snyder, 2013). One study of adolescents demonstrated that more severe levels of depression were concurrently and prospectively associated with lower levels of performance on attention tasks, with the latter mediated by interleukin-6 – suggesting that biological markers of inflammation may account for some of the heterogeneity that has been reported in research examining the interplay of mood and cognition (Mac Giollabhui et al., 2020). Research on subclinical dysphoria has yielded more equivocal findings – with EF deficits associated with mild depressive symptoms in some studies (Ganguli et al., 2009) but not in others (Bunce et al., 2008). Reflecting on our results, the high reactivity evidenced in our sample of undergraduate students may represent an ‘optimal zone’ for effectively utilizing moderate levels of negative mood while ignoring or more efficiently processing task-irrelevant negative information to adapt to the changing needs of the environment. These findings would likely not generalize to a clinical sample such as individuals with a diagnosis of depression or an anxiety disorder.

Our results, though telling a consistent story, should be interpreted in the context of several caveats. One limitation is that response inhibition was not measured prior to the mood induction, which precludes us from making any claims regarding potential changes in baseline inhibitory performance following the experimental manipulation. Similarly, it is impossible to discern whether individuals' baseline EF influenced the potency of the mood induction procedure. Another limitation is that students were generally feeling good at the time they entered our lab, as indicated by high ratings of positive mood and low ratings of negative mood at baseline. This resulted in there being more affective movement in the negative relative to positive mood induction conditions. There was a relatively modest increase in ratings of positive affect post-induction, but perhaps one that was not sufficiently strong to engender cognitive demands or induce a more heuristic processing style. This may explain why we did not find any main effects or interactions involving positive mood in our current investigation nor in our prior work. A final consideration is that negative mood was treated as a unitary construct in our study; however, a potentially informative direction for future work will be to adopt a more nuanced approach to the examination of mood states. The measurement of mood through single-item visual analogue scales had the benefit of being quick and thus not taking away from the mood induction procedure. However, the drawback is that it is hard to get a reliable and qualitative estimate of negative affect that would be achieved through utilizing a composite scale. The qualitative essence of a negative mood can make a difference in underlying motivation. Shields and colleagues, for example, reported that the induction of anxiety led to more perseverative errors on a card sorting task compared with the induction of anger (Shields et al., 2016).

Although both are negative moods high in arousal, anger is approach-based and anxiety is avoidant-based. The authors posit that these different motivational systems may exert differential effects on cognition and behaviour, citing other evidence showing greater depletion of cognitive resources in the context of avoidant relative to approach motivation (see Roskes et al., 2013). In their study, they speculate that induction of anxiety impaired sorting performance via an overall reduction in cognitive resources. Another study by Grahek and colleagues (2018) examining cognitive control has suggested difficulties with motivation and engagement (e.g., anhedonia) within depressed individuals leads to impaired task performance. Accordingly, it would be important to replicate the findings of Shields and colleagues (2016) with groups of individuals highlighting approach and avoidance motivation, as well as to explore the effect of deactivated motivational states such as anhedonia.

In sum, our study suggests that higher levels of emotional reactivity may buffer the potentially deleterious influence of negative mood on EF. Here and in our prior work, we have demonstrated that lower levels of emotional reactivity may lead to poorer performance with increased negative affect which is more trait-inconsistent for individuals at this end of the reactivity scale. Taken together, the consistency of our results points to emotional reactivity as an important moderator of mood-EF associations. Our understanding of this phenomenon is still preliminary, however, and we have suggested several ways in which it may be advanced in order to better understand what it is about emotional reactivity that may be helpful for some yet a hindrance to others. In so doing, we believe that our field will begin to unpack the complex interplay of emotional reactivity with affective cognition.

Chapter 3: Why might negative mood help or hinder inhibitory performance? An exploration of thinking styles using a Navon induction

3.1 Introduction

Executive functions (EF) are inter-related cognitive abilities necessary for identifying, progressing toward, re-evaluating and accomplishing goals (Jurado & Rosselli, 2007). Response inhibition is widely viewed as a core executive skill reflecting the interruption of naturally pre-potent or previously reinforced responses (Friedman & Miyake, 2004). Given consensus agreement that response inhibition is central to the EF construct, coupled with its associations with other fundamental aspects of EF (e.g., working memory and switching) as well as more complex behaviours (e.g., planning), understanding contextual influences on response inhibition is an important goal for research (Friedman & Miyake, 2017, 2004; Miyake & Friedman, 2012).

Although in-lab tasks of response inhibition have been developed to be non-emotional, the application of response inhibition in day-to-day life is often utilized in affective situations. Considerable work has demonstrated that the relationship between response inhibition and affect is reciprocal in nature (Pessoa, 2009). Studies using classic inhibitory paradigms have shown that responses to emotional stimuli can be successfully inhibited (e.g., Kalanthroff et al., 2013; Schulz et al., 2007), as can emotional responses to affective situations (e.g., von Hippel et al., 2005). This is evident in the normalcy bias, in which individuals assume they are safe and so under-react to potential or imminent threats (Drabek, 2012; Omer & Alon, 1994; Valentine & Smith, 2002). Indeed, during the COVID-19 pandemic governmental and individual responses to limit the spread of this disease have been greatly hindered by our reinforced response to *keep calm and carry on*. On the other hand, studies also have shown that emotional experiences have the potential to modulate inhibitory performance (e.g., Albert et al., 2010; Verbruggen & de Houwer, 2007).

Following from the above, our previous work explored the influence of mood on EF – including response inhibition – in studies examining natural variations in mood (Gabel & McAuley, 2018) and active manipulation of mood states (Gabel & McAuley, 2020). Although there were no main effects or interactions involving positive mood in either of our studies, negative mood was consistently associated with better performance for individuals higher in reactivity but the converse for those lower in reactivity. In the initial study we suggested that our findings incorporated the integration of two theoretical perspectives regarding the interplay of mood and cognition: mood-as-information theory which predicts that positive and negative moods engender different thinking styles that may be beneficial or detrimental to EF task performance pending the particulars of the task (e.g., Fredrickson, 2001; Schwarz & Clore, 1983) and cognitive load theory, which posits that increased intensity of both positive and negative mood states will interfere with cognitive tasks through task-unrelated thoughts or active emotion regulation (Curci et al., 2013; Mackie & Worth, 1989; Seibert & Ellis, 1991). A third theory regarding mood's relationship with cognition is that has been integrated into cognitive load and mood-as-information theories is the affective certainty model (Tamir & Robinson, 2004; Tamir et al., 2002). This theory proposes that trait-inconsistent mood states will interfere with performance on tasks of response inhibition. Emotional reactivity is a stable trait that reflects the rapidity, intensity, and duration of reactions to affective situations (Nock et al., 2008) – one that makes divergent predictions about the impact of negative mood on response inhibitory performance. Because negative affect is thought to be trait-consistent with those higher in emotional reactivity (Nock et al., 2008; Ripper et al., 2018), the occurrence of negative mood does not interfere with task performance and task performance increases as negative affect increases for these individuals (Gabel & McAuley, 2018; 2020).

Moreover, it is suggested that negative moods engender a more analytic thinking style that facilitates performance on EF tasks requiring close attention to detail. Given findings from our previous studies (Gabel & McAuley, 2018; 2020) it is possible that individuals higher in reactivity were able to utilize an analytic thinking style from increased negative affect without the corresponding increase in cognitive load because negative moods states are more likely trait-consistent for these individuals. For less reactive individuals, however, the occurrence of negative mood is comparatively atypical and so may be associated with increased cognitive demands that are detrimental to performance on the same EF tasks. Although these ideas explain our pattern of findings, they are necessarily speculative because thinking style was not explicitly examined in our prior work.

The current study goes one step further and explores the influence of thinking styles on inhibitory performance. Thinking styles were studied extensively in seminal work by David Navon (1977) using stimuli in which letters at the local level were embedded within the same or different letters at the global level (e.g., a large ‘H’ made up of either small ‘H’s or small ‘S’s, respectively). This research established that individuals have a bias toward processing information heuristically – for example, being significantly faster to respond in the global relative to local condition irrespective of stimulus congruity and, within the local condition, being especially slowed when local elements were incongruous with the global level (see Navon, 1977 experiment 3). Considering these findings from a practical perspective, it would be laborious to be constantly analyzing what something is made up of in order to determine its form and so having a global or heuristic bias makes intuitive sense.

There is a widely supported link between thinking styles and mood (Srinivasan & Hanif, 2010). People are generally happy and tend to think heuristically (Diener & Diener, 1996; Gasper & Clore, 2002; Xu et al., 2019). Experimental induction of positive emotions can also broaden attentional scope and lead to a stronger global bias in processing information (Fredrickson & Branigan, 2005; Rowe et al., 2007). Research has demonstrated that positive mood states are not necessarily wed to heuristic thinking styles such that this global precedence can be overridden through priming local features (Huntsinger et al., 2010; 2014; Isbell et al., 2016). Conversely, negative emotions are related to less heuristic thinking and a more analytic information processing style (Gasper & Clore, 2002; Rodriguez-Gomez et al., 2019; Smith et al., 2014). Hence, while positive and negative moods are typically related to differing thinking styles, thinking styles can also be manipulated independent from mood state.

In the current investigation, we used a Navon task to experimentally induce either a heuristic or analytic approach to information processing by requiring that participants respond to a preponderance of information at either a global or local level, respectively. Pre-induction, we expected to replicate our previous findings that individual differences in emotional reactivity moderate an association between natural variations in negative mood on inhibitory performance (Gabel & McAuley, 2018). Post-induction, we predicted that participants would demonstrate better inhibitory performance in the analytic compared with heuristic condition. Within each condition, however, we further expected to observe a different pattern of effects post-induction involving negative mood, inhibitory performance, and emotional reactivity. In the heuristic condition we expected that negative mood would predict better inhibitory performance for participants higher in reactivity and worse inhibitory performance for participants lower in reactivity. This prediction is based on the idea that increased negative mood will engender analytic thinking and counter the heuristic thinking style that is meant to be enhanced through the Navon induction (i.e., processing information at a global level) for participants who are highly-reactive. Conversely, negative affect should act as cognitive load for those lower in reactivity based on the idea that these emotional experiences will need to be regulated (e.g., rumination, cognitive reappraisal) as they are not typically experienced by these individuals. This would result in an interaction between negative mood and emotional reactivity on inhibitory performance. In contrast, in the analytic condition we expected that negative mood would predict better inhibitory performance irrespective of emotional reactivity. This prediction is based on the idea that negative mood engenders an analytic thinking style in high-reactive individuals which would be further enhanced through the Navon induction (i.e., processing information at a local level). For low-reactive participants, we expected that the induction would focus attention on local features of the task and override cognitive load that seems to be more typically associated with negative mood (e.g., rumination, cognitive reappraisal; Brinker et al., 2013; Lyubomirsky et al., 2003). This would result in a main effect of negative mood but no interaction between negative mood and emotional reactivity in the analytic condition. Consistent with our prior work, we did not expect positive mood to have an effect in either condition.

3.2 Method

Participants

Participants were recruited through a departmental pool of students enrolled in psychology courses at the University of Waterloo. A priori power analysis was conducted using G*Power (Faul et al., 2009). Because the size of group differences based on this induction was unknown, the power analysis was based on the average effect size of Gabel & McAuley (2018) for the interaction of negative affect and emotional reactivity on inhibitory performance (R^2

=.13). This effect should be replicated in the Heuristic condition given Navon’s (1977) research suggesting a global bias through natural variations in mood which are thought to be generally positive (Diener & Diener, 1996). Based on this model with α=.05 and β=.80 we estimated that we would need at least 79 participants in the Heuristic condition. We aimed to collect the same number of participants for the Analytic condition. In total, one-hundred sixty-eight undergraduates completed a 30-minute experimental procedure for course credit (M_{age} = 22.23 years, *SD* = 2.96 years, 81% female, 26% Caucasian 32% Asian, 23% Other).

Measures

Positive and Negative Affect Schedule (PANAS). This 20-item scale (Watson et al., 1988) asked participants to rate their experience of 10 positive adjectives (e.g., “excited”) and 10 negative adjectives (e.g., “afraid”) on a 5-point Likert scale ranging from *very slightly or not at all* (1) to *extremely* (5) over the past week. Responses were totaled within each subscale, which were internally consistent in our sample (positive affect: *M* = 31.0, *SD* = 7.16, 95% CI [29.90 – 32.10], Cronbach’s α = .87; negative affect: *M* = 22.84, *SD* = 7.77, 95% CI [21.63 – 24.03], Cronbach’s α = .88).

Task Stop Signal Task (Logan et al., 1984). Participants made a speeded choice key press response to a centrally presented stimulus (i.e., a pink or yellow star) except when the stimulus was followed by an auditory signal that cued them to cancel their response. Timing of this auditory signal (i.e., the stop signal), referred to as the stop signal delay (SSD), was initially set to 250 ms post-stimulus onset for all participants. The SSD was subsequently adjusted based on each participant’s response on the preceding stop trial: SSD was increased by 50 ms following a failure to inhibit and was decreased by 50 ms following a successful inhibit. Because timing of the SSD influences the likelihood of inhibitory success, having this dynamic tracking algorithm calibrated to each individual participant ensured that they were able to successfully inhibit their responses on approximately half of stop trials (see also Band, van der Molen, & Logan, 2003). The task was presented in three blocks that each included 16 (25%) stop trials and 48 (75%) go trials. Stop signal reaction time (SSRT) was calculated in ms as the mean SSD subtracted from the average time taken to correctly respond on non 'stop' trials (*M* = 298.42, *SD* = 64.16, 95% CI [286.24 – 310.60], Cronbach's α = .93).

Modified Navon Task (Navon, 1977). Participants were randomly assigned to the analytic or heuristic induction condition. Each trial began with a centrally positioned fixation cross for 500 ms. After disappearance of the fixation, a Navon stimulus appeared in the centre of the screen. In both conditions, these stimuli consisted of a large letter made up of seven smaller letters in height and five smaller letters in width (Appendix). Participants were instructed to press the 'H' response key if an H was apparent in either the global or local level and the 'L' response key if an L was apparent in either the global or local level. The stimulus remained on the screen until participants made a response or 2000 ms had elapsed. There was a blank inter-trial interval of 1000 ms and then the next trial began. The heuristic condition consisted of 75% global trials and 25% local trials. Conversely, the analytic consisted of 75% local trails and 25% global trials. This induction procedure took place between blocks 1 and 2 (40 trials) and blocks 2 and 3 (20 trials) of the Stop Signal task. The Navon induction has been shown to be short-lived which necessitated the utilization of two induction timepoints to ensure effectiveness across blocks of the Stop Signal task (Macrae & Lewis, 2002; Mundy, 2014; Perfect et al., 2007). The numbers of trials was chosen to ensure that the induction was effective whilst minimizing the potential for fatigue to subsequently influence performance on the Stop Signal task.

Emotion Reactivity Scale (ERS). Participants rated their reactions to 21 items (Nock et al., 2008) using a 5-point Likert scale ranging from *not at all like me* (0) to *completely like me* (4). Items reflected emotional sensitivity (e.g., “my feelings get hurt easily”), emotional persistence (e.g., “when something happens that upsets me, it’s all I can think about for a long time”), and emotional arousal/intensity (e.g., “when I experience emotions I feel them very strongly/intensely”), which were summed to create a total score (M = 32.96, SD = 18.49, 95% CI [30.10 – 35.82], Cronbach’s α = .95).

Demographic Questionnaire. Included were questions regarding age, sex, ethnicity, and medical history.

Procedure

Participants were randomly assigned to a heuristic (n = 85) or analytic (n = 83) thinking style induction condition. All participants completed tasks in the same fixed order. They first completed the Positive and Negative Affect Schedule and the Emotion Reactivity Scale. They then completed a baseline block of the Stop Signal Task, followed by the thinking style induction in which they completed a variant of the Navon task (Navon, 1977). This was followed by another block of the Stop Signal task, a repetition of the modified Navon task, and then a final Stop Signal block. Participants then completed the Demographic Questionnaire.

3.3 Results

All analyses were completed using SPSS version 26. Data were missing for one participant on the Stop Signal task when the program crashed. Another six participants were excluded from analysis because they did not follow instructions on the Stop Signal task (e.g., responded immediately or were overly cautious resulting in less than 10% correct go trials). Scores on self-report measures and task response times were within reasonable limits of normality (i.e., 95% CI of skew and kurtosis <1.96, Kolmogorov-Smirnov $p > .05$) and no univariate or multivariate outliers were observed in either group. The final sample of 161 participants included 81 participants in the heuristic condition and 80 participants in the analytic condition.

Assessment of baseline group differences

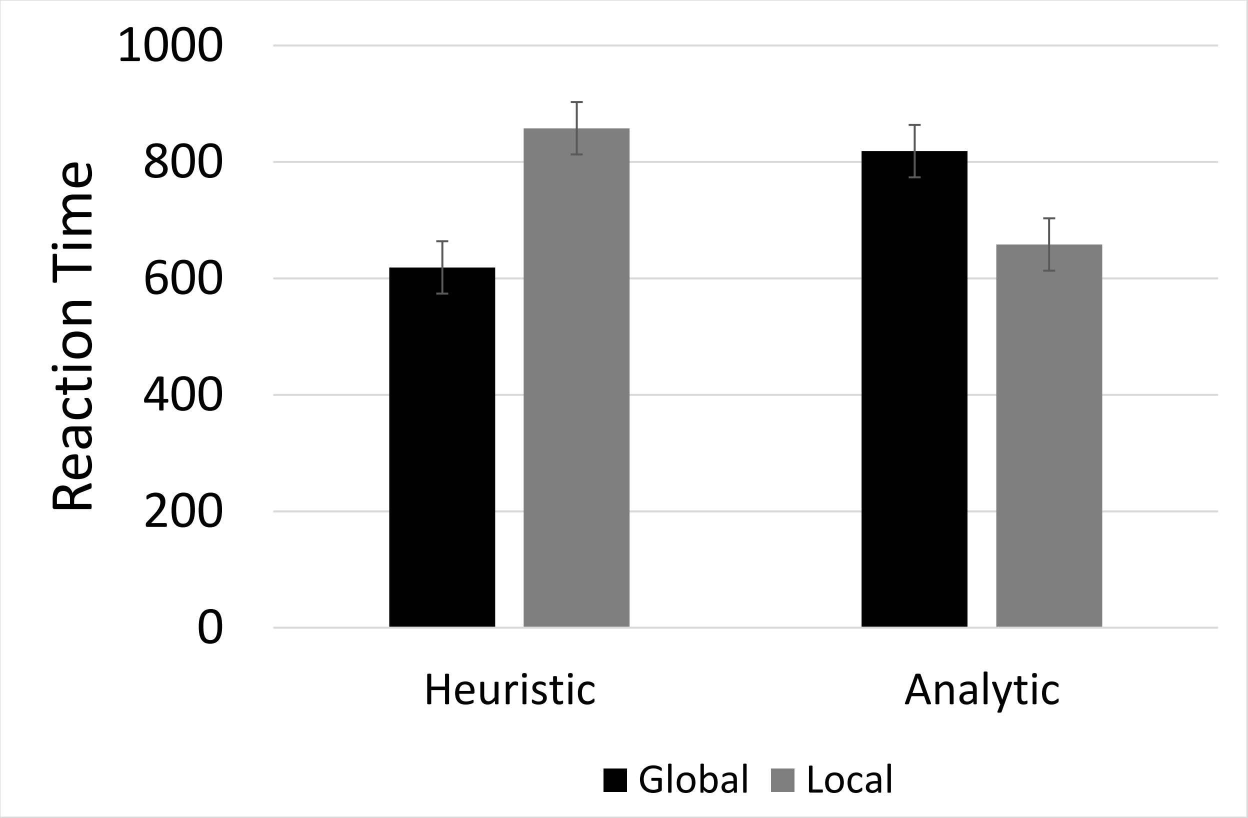
First, a one-way ANOVA was used to ensure that participants did not differ on emotional reactivity or positive and negative affect between conditions. Results indicated no group differences on these variables (p’s > .23). Next, a paired samples t-test was analyzed as a check to see if positive mood was significantly higher than negative mood in both conditions. As expected, positive mood was significantly higher than negative mood in both the analytic (t [79] = -7.24 $p < .01$) and heuristic conditions (t [80] = -6.45 $p < .01$). Participants averaged 2.3 on negative affect items (i.e., a little) and 3.1 on positive items (i.e., moderately) across conditions. Additionally, correlational analyses were done to confirm that emotional reactivity was correlated with negative, but not positive mood in both conditions. Results support this hypothesis with emotional reactivity related to negative but not positive mood in both the heuristic (negative: r [81] = .59, $p < .01$; positive: r [81] = .04, $p =.71$). and analytic conditions (negative: r [80] = .60, $p < .01$; positive: r [80] = -.15, $p = .20$). Applying a Fisher’s r-z transformation confirms that the correlation between emotional reactivity and negative and positive affect were of significantly different magnitude (heuristic: $z = 3.98$, $p < .01$; analytic: $z = 5.24$, $p < .01$).

Manipulation check

Effectiveness of the thinking style induction was next evaluated using a 2x2 mixed factors ANOVA, with Navon task trial type (global, local) as the within-subjects factor and condition (analytic, heuristic) as a between-group factor. Emotional reactivity, positive and negative affect and the interaction of emotional reactivity and negative affect were added as potential moderators of the interaction between trial type and condition. As predicted, the two-way interaction was significant ($F[1, 153] = 231.28$, $p < .01$) such that those in the heuristic condition responded significantly faster to global trials while those in the analytic condition responded significantly faster to the local trials (see Figure 3.1). No moderators listed above significantly predicted this relationship (p's > .36). These results suggest that the induction was effective at inducing the target thinking style (heuristic or analytic) regardless of pre-existing affective experience or emotional reactivity.

Figure 3.1.

Bar chart representing between group differences in average reaction times to local and global trials. Error bars reflect +/- 2 standard errors of the mean.



Emotional reactivity as a moderator of negative mood and inhibitory performance at baseline

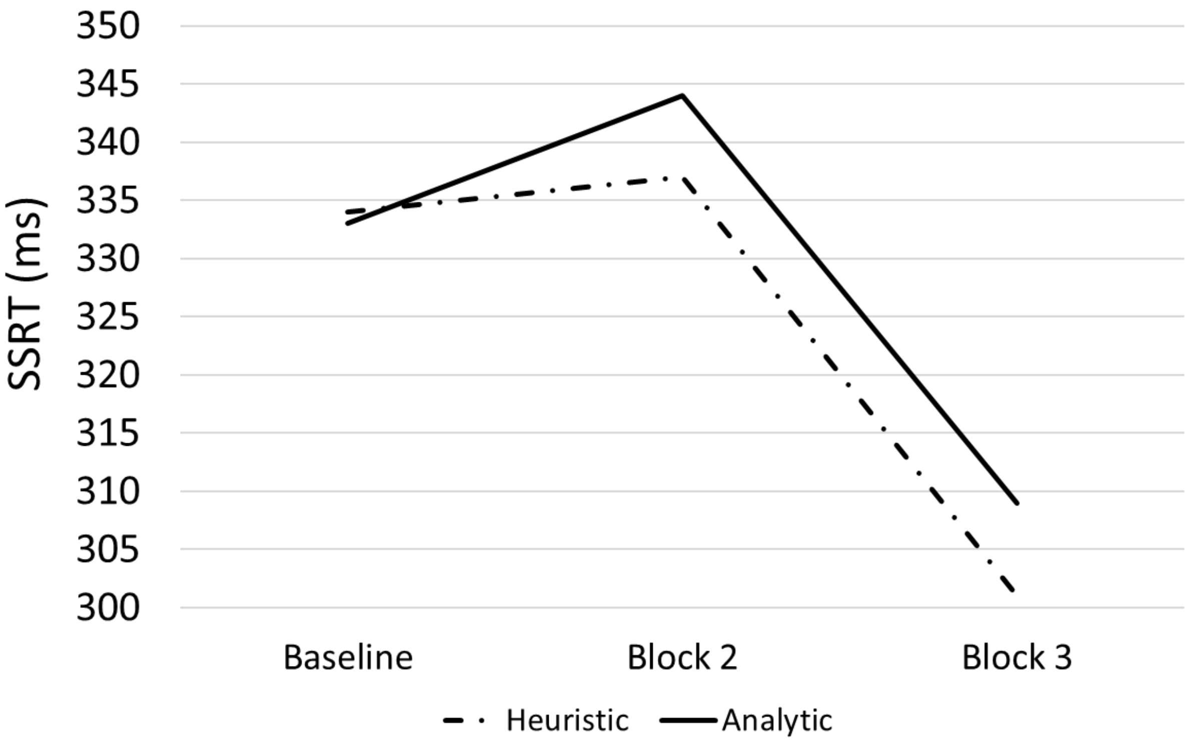
To test the hypothesis that emotional reactivity would moderate the association of negative affect and inhibitory performance at baseline, positive and negative affect, as well as emotional reactivity and the interaction of emotional reactivity and negative affect were entered into a regression model predicting baseline SSRT. The model at baseline was not statistically significant, $R^2 = .02$, $F[4, 153] < 1$, $p = .643$. No direct effects of positive or negative mood, emotional reactivity, or a mean-centred interaction between negative mood and emotional reactivity were present at baseline SSRT (*p*'s > .37).

Comparison of inhibitory performance across conditions

To test the hypothesis that an analytic thinking style would lead to faster (i.e., better) performance on the Stop Signal task relative to a heuristic thinking style, a 2x3 repeated measures ANOVA with time (baseline, post-induction 1, and post-induction 2 SSRT) as the repeated measures factor and condition (analytic, heuristic) as a between subjects factor was utilized. There was no significant effect of condition ($F[1, 157] < 1$, $p = .51$; see Figure 3.2). There was a significant main effect of time ($F[2, 314] = 22.45$, $p < .01$), such that SSRT was not different from baseline to post-induction 1 ($t[157] = -1.50$, $p = .14$) but was significantly faster from post-induction 1 to post-induction 2 ($t[160] = 6.60$, $p < .01$) across conditions. The interaction of time with condition was not significant ($F[2, 314] < 1$, $p = .64$).

Figure 3.2.

Repeated measures ANOVA demonstrating differences in SSRT over time between heuristic and analytic conditions.



Emotional reactivity as a moderator of negative mood and post-induction inhibitory performance in the heuristic condition

Next, hierarchical regression was used to test the hypothesis that emotional reactivity would moderate an association between negative mood and post-induction SSRT (i.e., average SSRT across blocks 2 and 3) in the heuristic condition. After controlling for positive affect in step 1, negative affect and emotional reactivity were entered as predictors in step two and the mean-centred interaction of negative affect and emotional reactivity was entered as a predictor in step three. Overall, the model predicted 13% of the variance in Stop Signal task performance (R^2

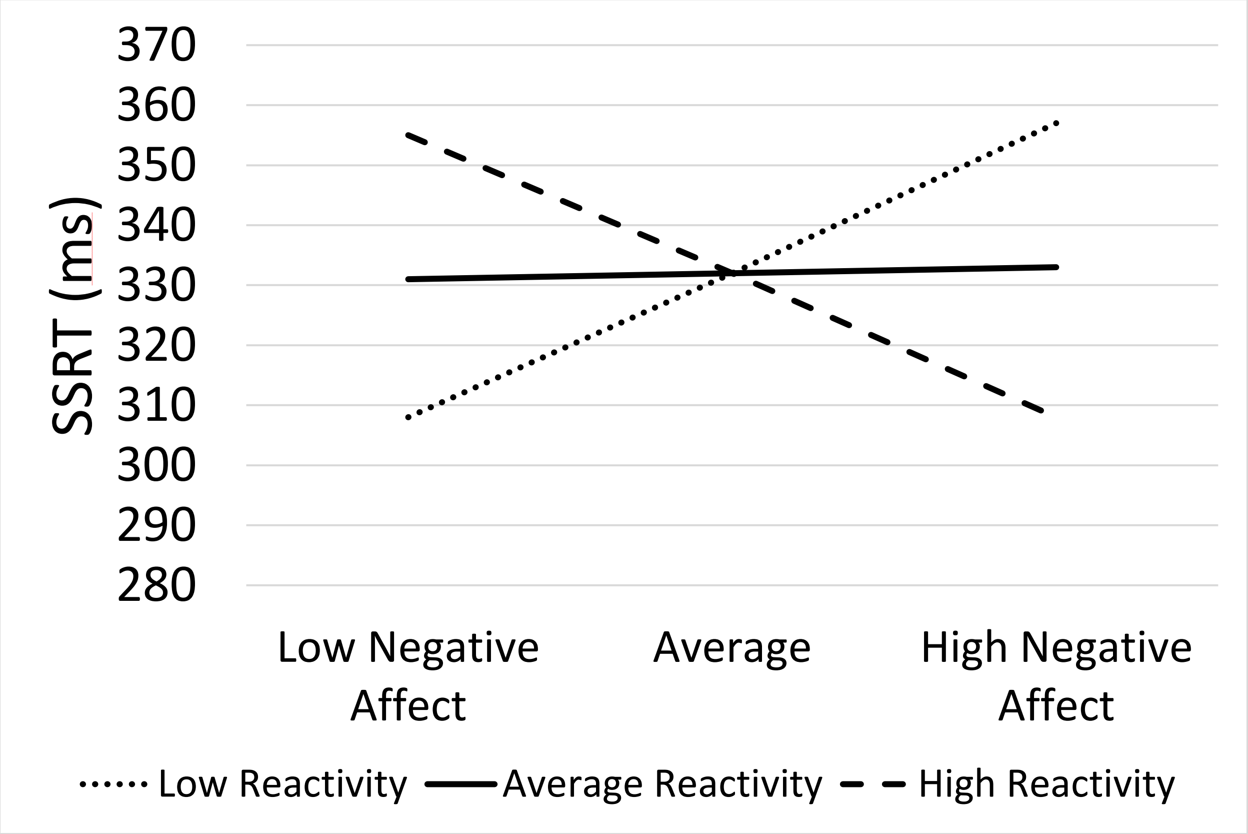
= .13, *F* [4, 76] = 2.85, *p* = .03). There was no effect of positive affect at step one (R^2 = .00, *B* = .63, *SE* = 1.11, *t* < 1, *p* = .57, 95% CI [-1.59 – 2.85]). Negative affect and emotional reactivity did not add a significant amount of variance in step two (ΔR^2 = .02, ΔF[2, 77] < 1, *p* =.39, negative affect: *B* = -1.34, *SE* = 1.26, *t* = -1.06 *p* = .29, 95% CI [-3.85 – 1.17], emotional reactivity: *B* = -.04, *SE* = .54, *p* = .94, 95% CI [-1.11 – 1.13]). However, there was a significant interaction between negative affect and emotional reactivity at step three (ΔR^2 = .10, ΔF[1, 76] = 8.96, *p* <.01, *B* = -23.64, *SE* = 7.90, *t* = -2.99, *p* < .01, 95% CI [-39.38 – -7.91]).

Using PROCESS version 3.4 (Hayes, 2014), simple slopes for the regression of negative affect on SSRT were tested at low (-1 SD below the mean), average, and high (+1 SD above the mean) levels of emotional reactivity. There was no significant effect of negative affect at low levels of emotional reactivity, although numerically these individuals tended to do worse on the Stop Signal task the more negative affect they experienced (*B* = 3.14, *SE* = 1.92, *t* = 1.64, *p* = .11, 95% CI [-.68 – 6.96]). There also was no effect for average levels of emotional reactivity (*B* = -.09, *SE* = 1.29, *t* < 1, *p* = .94, 95% CI [-2.48 – 2.66]). However, consistent with our predictions, increasing levels of negative affect significantly predicted better Stop Signal performance for high reactive individuals in this condition (*B* = -2.95, *SE* = 1.31, *t* = -2.25, *p* = .03, 95% CI [-5.57 – -.33]; see Figure 3.3).

These results support the hypothesis that negative mood would predict better inhibitory performance for those higher in reactivity and worse inhibitory performance for those lower in reactivity in the heuristic conditions. To ascertain whether our findings were attributable to negative mood enhancing analytic thinking in participants higher or lower in reactivity, thereby countering the heuristic manipulation, we returned to the Navon induction data and examined the trends of negative affect, emotional reactivity and the interaction of emotional reactivity and negative affect on the residual of global RT controlling for local RT. The overall model predicted 3.7% of the variance in induction effectiveness ($R^2 = .04$, $F [3, 77] = 2.24$, $p = .41$). Neither Negative affect ($B = -1.01$, $SE = 2.14$, $t < 1$, $p = .64$, 95% CI [-5.28 – 3.25]), emotional reactivity ($B = -.73$, $SE = .86$, $t < 1$, $p = .40$, 95% CI [-2.43 – .98]), nor the interaction of emotional reactivity and negative affect ($B = -4.02$, $SE = 12.89$, $t < 1$, $p = .76$, 95% CI [-29.68 – 21.65]) significantly predicted global RT. These results were unchanged when difference scores (i.e., global RT – local RT) were analyzed.

Figure 3.3.

Simple slopes demonstrating the regression of individual differences in negative affect on inhibitory performance moderated by emotional reactivity, with positive affect entered as a covariate.



Negative mood and post-induction inhibitory performance in the analytic condition

A similar hierarchical regression was used to test the hypothesis that negative affect would facilitate post-induction inhibitory performance (i.e., average SSRT across blocks 2 and 3) in the analytic condition. Overall, the model predicted 7.7% of the variance in Stop Signal performance (R^2 = .08, F[4, 75] = 1.55, p = .20). Positive affect did not predict a significant amount of the variance at step one (R^2 = .005, B = -.71, SE = 1.08, t < 1, p = .51, 95% CI [-2.85 –

1.44]). Emotional reactivity and negative affect added 6.9% variance to the overall model (ΔR^2 = .07, ΔF[2, 75] = 2.76, *p* =.07) with increased negative mood predicting better performance (*B* = -2.70, *SE* = 1.21, *t* = -2.23 *p* = .03, 95% CI [-5.11 – -.28]), and no effect of emotional reactivity (*B* = .388, *SE* = .522, *t* < 1 *p* = .46, 95% CI [-.65 – 1.43]) within the analytic condition. As predicted there was no interaction within this condition (ΔR^2 = .00, ΔF[1, 75] < 1, *p* =.58).

These results support the hypothesis that negative mood would predict better inhibitory performance irrespective of emotional reactivity. To ascertain whether our findings were attributable to negative mood engendering a more analytic thinking style that was further enhanced through the analytic manipulation, we returned to the Navon induction data and examined the association of negative affect and local RT controlling for global RT. The overall model predicted 6.7% of the variance in induction effectiveness (R^2 = .07, *F* [3, 74] = 1.76, *p* = .16). Neither Negative affect (*B* = 1.31, *SE* = 2.24, *t* < 1, *p* = .56, 95% CI [-3.15 – 5.77]), nor emotional reactivity (*B* = -.86, *SE* = .88, *t* < 1, *p* = .33, 95% CI [-2.60 – .89]) significantly predicted local RT, although there was a trend towards an interaction of emotional reactivity and negative affect (*B* = -25.36, *SE* = 12.95, *t* = -1.96, *p* = .05, 95% CI [-51.17 – .45]). Within this interaction lower levels of negative affect had no relationship with performance across reactivity (*B* = .50, *SE* = 1.11, *t* < 1, *p* = .66, 95% CI [-1.71 – 2.70]). There also was no effect for average levels of emotional reactivity (*B* = -.84, *SE* = .88, *t* < 1, p = .34, 95% CI [-2.60 – .92]). However, increasing levels of negative affect tended to predict better local RT performance as reactivity increased (*B* = -2.18, *SE* = 1.14, *t* = -1.91, p = .06, 95% CI [-4.45 – .09]). These results were unchanged when difference scores (i.e., local RT – global RT) were analyzed.

3.4 Discussion

Our study was undertaken to directly examine the potential impact of thinking styles on inhibitory performance. At the outset we expected that SSRTs would be faster in the analytic relative to heuristic conditions. Counter to what was predicted, we found that inhibitory performance was comparable across groups. Research has both supported and refuted the validity of Navon-like inductions for engendering these thinking styles (e.g., Klauer & Singmann, 2015; Majima, 2015). Although the forgoing may suggest that our induction was ineffective, our manipulation check suggests otherwise: participants were unequivocally faster on global trials in the heuristic condition and on local trials in the analytic condition. Another possibility is that analytic thinking is not beneficial for performing the Stop Signal task; however, this appears inconsistent with the significant findings we describe below. We suggest that a more parsimonious and plausible explanation of our null result is that comparison of groups obfuscated the effect of individual differences that were apparent upon examining SSRT within each condition. Other research has similarly demonstrated that while group level comparisons offer a more conservative and better controlled estimate of true effects, they reduce power of detecting true differences within the population of interest (Charness et al., 2012).

Within the heuristic condition, we expected that emotional reactivity would moderate an association between negative mood and inhibitory performance. Consistent with this hypothesis and our prior work (Gabel & McAuley, 2018, 2020), highly reactive individuals performed better the more negative affect they were experiencing and less reactive individuals showed the opposite effect. Previously, we suggested that this interaction could be explained by the integration of two theoretical perspectives: affective certainty theory which postulates that trait-inconsistent mood states interfere with task performance (Tamir & Robinson, 2004; Tamir et al.,

2002) and cognitive load theory, which proposes that increased intensity of mood states will increase the likelihood of task unrelated thoughts and interfere with task performance (Curci et al., 2013; Seibert & Ellis, 1991). The integration of these two theories suggests that trait-inconsistent moods will increase the likelihood of task-unrelated thoughts or active emotion regulation which will then interfere with performance on tasks of response inhibition. Findings from our previous work were also not inconsistent with mood-as-information theory, which posits that negative mood engenders analytic thinking that benefits tasks requiring close attention to detail (Bohner et al., 1994; Park & Banaji, 2000; Schwarz & Clore, 1983; 2003). This led us to speculate that individuals higher in emotional reactivity, who are more accustomed to negative affect, might be able to better utilize a more analytic thinking style as they are less likely encumbered by cognitive load (Gabel & McAuley, 2018; 2020). Reflecting on our results in the heuristic condition of this study, we observed reactivity as a moderator of the association between negative affect and response inhibition such that individuals higher in reactivity performed better with increasing levels of negative affect while individuals lower in reactivity showed an opposing pattern. Across levels of reactivity, the pattern of results are consistent with affective certainty and cognitive load hypotheses which replicates previous findings (Gabel & McAuley, 2018; 2020; Tamir & Robinson, 2004). For individuals higher in reactivity these results are also consistent with research supporting a connection between negative affect and analytic thinking (Bless & Burger, 2017; Gasper & Clore 2002; Isbell et al., 2005; Srinivasan & Hanif, 2010). As identified by Bless and Burger (2017) positive mood is related to heuristic processing which relies more on pre-existing knowledge structures while negative mood promotes an analytic style which focuses more on situation-specific information. A novel task of response inhibition, such as the Stop Signal task, relies heavily on situation-specific information (i.e., waiting for the beep) and therefore would likely benefit from an analytic thinking style promoted through increased negative affect as was observed for high-reactive individuals in the current study and in Gabel and McAuley (2018; 2020). Furthermore, several studies have noted that natural variations in mood are typically quite positive (Diener & Diener, 1996; Fredrickson & Brannigan, 2005; Gasper & Clore, 2002; Huntsinger et al., 2010) and that there is also a global/heuristic bias to processing information (Isbell et al., 2016; Kimchi, 1992; Navon, 1977; Oliva & Torralba, 2006). Accordingly, it is not surprising that there was a replication of the effects observed in Gabel & McAuley (2018) across levels of reactivity even with the addition of the heuristic induction.

Within the analytic condition, we expected that negative affect would be the sole predictor of inhibitory performance irrespective of level of emotional reactivity. This hypothesis was supported by our findings and is consistent with our suggestion that pre-induction negative mood would engender an analytic thinking style, thereby strengthening the potency of the Navon induction for high-reactive individuals and countering some of the cognitive load that is more typically associated with negative mood for low-reactive individuals. In the latter, it may have been the case that the analytic induction helped to narrow their focus to local features in the task at hand, overriding the cognitive load that appears to be more typically associated with negative mood for these individuals (e.g., rumination; Brinker et al., 2013; Lyubomirsky et al., 2003). Thus, similar to what was observed by Schwarz and Clore (1983) the analytic induction might have shifted processing from internal issues (e.g., rumination, worry) to situation-specific information (e.g., identifying local features) which aided in subsequent response inhibitory performance. Additionally, as pointed out through Isbell and colleagues' (Isbell et al., 2016; Isbell et al., 2013) affect-as-cognitive-feedback account, global or heuristic processing paired with a negative response leads to a change in processing from global to local. Accordingly, another possibility is that for low-reactive individuals, error detection during the Stop Signal task does not typically elicit a strong negative arousal response which fails to switch to local processing unless individuals are primed to utilize an analytic thinking style. Conversely, high-reactive individuals experience a negative arousal response to errors which primes or accentuates an analytic thinking style and improves inhibitory performance.

This study contributes to our understanding of the complex interplay between affect and cognition by identifying thinking style as one of several likely mechanisms that explains why negative mood has the potential to help or hinder cognitive task performance. Our findings, though generally consistent with our predictions, should be interpreted within the context of several limitations to be addressed in future work. Others have suggested that a between-subjects research design might be suboptimal for detecting differences in performance based on thinking style induction. We may have achieved null results due to increased between-subjects error and reduced power to detect effects (Charness et al., 2012). Also given that there are no obvious demand characteristics in the Navon induction, a within-subjects design would not have been inappropriate. Moreover, since thinking style inductions are thought to be short-lived and reversable (Huntsinger et al., 2010; 2014; Isbell et al., 2016), a superior design would be to have both heuristic and analytic conditions as within-subjects factors in a future study so long as the order of these conditions is counterbalanced. As a further consideration, future research might look at how discrete emotional responses to errors affect this relationship. As mentioned, the affect-as-cognitive-feedback model (Isbell et al., 2013; 2016) could help to explain how within-task affective responses to errors paired with pre-existing mood states (i.e., positive or negative) might interact to predict performance differently based on differences in emotional reactivity.

The current study is limited in the sense that mood was only rated at baseline. Future studies might consider including mood checks during EF tasks to see how errors are affecting mood and subsequent performance. As a final consideration, future research should examine motivational and arousal information that might underly how positively or negatively valenced moods influence thinking style. Research has suggested that this information might be more important than emotional valence in determining thinking style (Gable & Harmon-Jones, 2010a; Gable & Harmon-Jones, 2010b; Gable et al., 2015; Isbell et al., 2016; McKasy, 2020), a finding that has translated to tasks of executive functioning (Shields et al., 2016).

Chapter 4: The influence of affective and motivational states on response inhibition performance

4.1 Introduction

Purposeful behaviour in everyday life is facilitated by executive functions (EF), a collection of inter-related skills that allow us to consider multiple perspectives – including that of past, present and future – which help us to identify, evaluate, progress toward, and attain goals (Jurado & Rosselli, 2007). Although EF is comprised of myriad skills (Goldstein et al., 2014), response inhibition is widely viewed as central to the construct and has been conceptualized as the foundation upon which other executive skills develop (Miyake & Friedman, 2012). Response inhibition refers to the cessation of naturally pre-potent or previously reinforced behaviours that are incompatible with a given goal (Nigg, 2017; Verbruggen & Logan, 2008). Resisting the customary behaviour of shaking someone's hand during a pandemic would be a pertinent example of response inhibition. Because response inhibition is necessarily applied in situations that are novel, difficult, dangerous, require planning, and/or necessitate troubleshooting (e.g., Burgess, 2004), understanding contextual influences on inhibitory success is an important goal for research.

Previous work in our lab has examined affective contributions to inhibitory control. By capitalizing on natural variations in mood (Gabel & McAuley, 2018) and experimentally inducing mood states (Gabel & McAuley, 2020), our work has demonstrated that negative affect has the potential to help or hinder inhibitory performance depending on one's level of emotional reactivity. Emotional reactivity is defined as the rapidity, intensity, and duration of reactions to affective situations (Wheeler et al., 1993; Nock et al., 2008). We have consistently found that individuals lower in reactivity experience a decrement in inhibitory performance with increasing levels of negative affect, whereas individuals higher in reactivity typically demonstrate the converse pattern. To explain this pattern of findings, we have hypothesized that individuals higher in reactivity may be less distracted by negative mood because they experience more frequent and long-lasting negative mood states (Compas et al., 2004; Howland et al., 2017) – that is when mood is trait-consistent performance improves. Moreover, theoretical accounts suggest that negative moods signify threat and engender a more analytic thinking style (e.g., Schwarz & Clore, 2003) but also have the potential to be cognitively depleting (e.g., Stahl et al., 2012). As such, it may be the case that individuals higher in reactivity use the informational significance of a negative mood to invest more attention into the task at hand whereas individuals lower in reactivity experience negative mood as trait-inconsistent and this mood causes cognitive load as they find their attention drawn toward distracting thoughts (e.g., rumination) or engaged in active emotion regulation (e.g., cognitive reappraisal) that interfere with task performance (Brinker et al., 2013; Curci et al., 2013; Lyubomirsky et al., 2003; Seibert & Ellis, 1991).

While our work suggests that emotional valence is one factor that influences response inhibition and related executive skills, there is evidence from other work that EF may be differentially influenced by different high-arousal negative mood states. For example, research by Shields and colleagues (Shields et al., 2016) demonstrated that anxiety but not anger interfered with performance on a variant of the Wisconsin Card Sort Task – a classic neuropsychological measure of EF. The authors attributed their findings to different motivational systems activated by these two emotions. Motivation underlying affect has been identified as a vital component of emotion with approach and avoidance motivation systems being flagged for consideration above and beyond arousal and valence (Elliot et al., 2013; Gable et al., 2015; Harmon-Jones et al., 2009; Harmon-Jones et al., 2013). In terms of discrete emotions, anger and anxiety both invoke a strong negatively valanced arousal response that potentiate one of three different options for dealing with threat (Cannon, 1929). Anxiety typically involves avoidance of threat by freezing or actively fleeing, whereas anger more commonly entails approaching threat in order to nullify it. Because anxiety and anger tap into different motivational systems – avoidance and approach motivation, respectively – these emotions have the potential to affect our thinking and approach to problem solving in different ways (Bossuyt et al., 2014; Gable et al., 2015; Verbruggen & de Houwer, 2007). Taking this one step further, anger (approach-motivation) may be more likely than anxiety (avoidance-motivation) to bolster response inhibition and related executive skills when used to facilitate goal-oriented behaviours (Bossuyt et al., 2014).

While these two high arousal negative emotional states differ in underlying motivation and perhaps their impact on response inhibitory performance, it is interesting to consider how this relationship would be affected by emotional reactivity. The aforementioned studies in our lab suggest divergent predictions between high- and low-reactive individuals for negative affect generally speaking. Although we have yet to look at negative affective states with different underlying motivational systems, we have induced negative affect through remembering an upsetting event (e.g., doing poorly on a test; Gabel & McAuley, 2020) which is more likely be in line with avoidance-motivation. Accordingly, we might expect individuals low in reactivity to be more highly affected by anxiety (avoidance-motivated) via cognitive load, whereas anger (approach-motivation) might bolster response inhibition regardless of individual differences in emotional reactivity.

The current study aims to replicate and extend the findings of Shields and colleagues (2016) by examining whether anger and anxiety interact with emotional reactivity to influence inhibitory performance. Although both emotions are negative in valence and high in arousal, we anticipate that induction of anger will activate the approach-motivation system whereas induction of anxiety will activate the avoidant-motivation system. We also include induction of boredom, which is a low arousal, approach-oriented emotional experience that signals an individual to change their state or become engaged with something interesting (Bench & Lench, 2013). While it shares some similarities with anger in that it is typically approach oriented, it differs in that it tends to broaden rather than narrow cognitive scope (Gable & Harmon-Jones, 2010b; Gasper & Middlewood, 2014). Consistent with Shields et al. (2016) we expect that inhibitory performance will be best in the anger condition, worst in the anxiety condition, and intermediate in the boredom condition. Based on previous research in our lab (McAuley & Gabel, 2018; 2020), we further anticipate that emotional reactivity will predict improved inhibitory performance differently for those higher and lower in reactivity. Specifically, we expect that individuals lower in reactivity will perform best in the anger condition and worst in the anxiety condition while individuals higher in reactivity will perform similarly across conditions. Additionally, it is expected that individual differences in negative affect in the anxiety condition will affect performance negatively with increasing levels, while increasing experience of negative affect in the anger condition should affect performance positively.

4.2 Methods

Participants

Participants were recruited through a departmental pool of students enrolled in psychology courses at the University of Waterloo. Power was determined through G*Power (Faul et al., 2009) software based on the average effect size of emotional reactivity, negative affect and their interaction on response inhibition (R^2 =.089; Gabel & McAuley, 2020 and a study by Shields et al. (2016) predicting differences between anger, anxiety and neutral conditions on response inhibition (partial eta^2 =.10). Based on this model we expected a medium effect size *f* = .25 with α = .05 and β = .80 and estimated that at least 55 participants would be needed in each condition (N=165). One-hundred seventy-six undergraduates completed a 30-minute experimental procedure for course credit (M_{age} = 20.10 years, *SD* = 2.25 years, 86% female, 30% Caucasian, 26% East Asian, 20% Other).

Measures

Brief Emotional Circumplex (BEC). This 20-item in-house scale was developed and utilized instead of more traditional emotion scale (e.g., PANAS) to get information about specific emotion adjectives (i.e., anger, boredom) while maintaining a similar emotion structure to the PANAS. The scale asked participants to rate their current experience of 10 positive emotional adjectives (e.g., motivated, tranquil) and 8 negative emotional adjectives (e.g. angry, anxious) on a 5-point Likert scale ranging from *very slightly or not at all* (1) to *extremely* (5). Two 'neutral' emotions (i.e., tired and bored) were included as a manipulation check for the boredom condition. Responses were averaged within the positive and negative subscales, which were internally consistent in our sample (positive affect: baseline α = .85, post-induction α = .89, post-task α = .84; negative affect: baseline α = .79, post-induction α = .80, post-task α = .84).

Emotion Reactivity Scale (ERS; Nock et al., 2008). Participants rated their reactions to 21 items using a 5-point Likert scale ranging from *not at all like me* (0) to *completely like me* (4). Items reflected emotional sensitivity (e.g., "my feelings get hurt easily"), emotional persistence (e.g., "when something happens that upsets me, it's all I can think about for a long time"), and emotional arousal/intensity (e.g., "when I experience emotions I feel them very strongly/intensely"), which were averaged to create a mean score (*M* = 1.58, *SD* = .81, Cronbach's α = .95).

Stop Signal Task (Logan et al., 1984). Participants made a speeded choice key press response to a centrally presented stimulus (i.e., a pink or yellow star) except when the stimulus was followed by an auditory signal that cued them to cancel their response. Timing of this auditory signal (i.e., the stop signal), referred to as the stop signal delay (SSD), was initially set to 250 ms post-stimulus onset for all participants. The SSD was subsequently adjusted based on each participant's response on the preceding stop trial: SSD was increased by 50 ms following a failure to inhibit and was decreased by 50 ms following a successful inhibit. Because timing of the SSD influences the likelihood of inhibitory success, having this dynamic tracking algorithm calibrated to each individual participant ensured that they were able to successfully inhibit their responses on approximately half of stop trials (see also Band, van der Molen, & Logan, 2003). The task was presented in four blocks that each included 8 (25%) stop trials and 24 (75%) go trials. Stop signal reaction time (SSRT) was calculated in ms as the mean SSD subtracted from the average time taken to correctly respond on non 'stop' trials (*M* = 347.50, *SD* = 67.37, Cronbach's α = .96).

Demographic Questionnaire. Included were questions regarding age, sex, ethnicity, and medical history.

Procedure

All participants completed tasks in the same fixed order. They first completed the Emotion Reactivity Scale and Brief Emotional Circumplex (BEC) scale. As per the mood induction in Shields et al., (2016), participants were then randomly assigned to a condition in which they were instructed to spend 5-minutes writing about a recent event that made them feel anxious (anxiety condition, n = 58), angry (anger condition, n = 59), or in which they wrote letters of the English alphabet in alphabetical order (boredom condition, n = 59) (e.g., Bodenhausen et al., 1994; Moons & Shields, 2015; Shields et al., 2016; Tiedens & Linton, 2001). The boredom condition was adapted to match the timing of the other two conditions while introducing a face-valid task to induce boredom. Participants then completed a post-induction BEC, the Stop Signal task, a post-task BEC, and then the demographic questionnaire.

4.3 Results

Data Cleaning and Normality Analyses

All analyses were completed using SPSS version 26. The Stop Signal task program crashed for two participants who were subsequently removed from analysis. Another two participants were excluded from analysis because they did not follow task instructions (i.e., responded in under 100ms on average for go trials, or were overly cautious resulting in less than 10% correct go trials). Four participants reported not being activated by the emotional writing induction task (anxiety, n = 3, anger, n = 1) and were removed from analysis.

Scores on a composite of post-induction and post-task negative affect in both the boredom and anger conditions violated assumptions of normality for skew and kurtosis (Kolmogorov-Smirnov $p < .001$). A log transformed version of this composite improved normality of the distribution in both the boredom (D = .202 to D = .154) and anger (D = .173 to D = .130) conditions; however, the *p*-value in both conditions remained below .05 so the non-log transformed negative affect composite was used for the following analyses. Response times from the Stop Signal task and all other self-report measures were within reasonable limits of normality (i.e., 95% CI of skew and kurtosis <1.96, Kolmogorov-Smirnov $p > .05$). There were 10 multivariate outliers observed in the dataset (anxiety, n = 4, anger, n =3, boredom, n = 3). These participants were removed from subsequent analyses. The final sample of 158 participants included 55 participants in the boredom condition, 52 participants in the anger condition and 51 in the anxiety condition. The pattern of results was unchanged by inclusion of the full sample or use of the log transformed negative affect variable.

Group Differences and Manipulation Check

First, a one-way ANOVA was used to ensure that participants did not differ on emotional reactivity, or baseline levels of positive and negative affect between conditions. Results indicated no group differences on these variables (p's > .34). Next, paired samples t-tests were analyzed as a check to see if positive mood was significantly higher than negative mood at baseline across conditions. As expected, positive mood was significantly higher than negative affect at baseline in the anger (t [51] = -10.36 $p < .001$), anxiety (t [50] = -9.77 $p < .001$) and boredom conditions (t [54] = -10.85 $p < .001$). Participants averaged 1.4 on the negative affect subscale (i.e., very little/a little) and 2.5 on the positive affect subscale (i.e., a little/moderately). Correlational analyses were done to confirm that emotional reactivity was correlated with baseline negative, but not positive mood across conditions. Results support this hypothesis with emotional reactivity related to negative (r [158] = .40, $p < .001$) but not positive mood (r [158] = -.02, p =.77) at baseline. There was no difference in the magnitude of these correlations across conditions for positive affect (anger condition: r [52] = -.13, p =.37; boredom condition: r [55] = -.01, p =.92; anxiety condition: r [51] = .04, p =.79) or negative affect (anger condition: r [52] = .44, $p < .01$; boredom condition: r [55] = .41, $p < .0$; anxiety condition: r [51] = .36, $p < .01$). Applying a Fisher's r-z transformation confirms that the correlation between emotional reactivity and negative and positive affect were of significantly different magnitude overall ($z = 3.91$, $p < .01$) or within conditions (anger: $z = 2.98$, $p < .01$; boredom: $z = 2.27$, $p = .01$; anxiety: $z = 1.65$, $p = .05$).

Next, paired samples *t*-tests of boredom, anger, anxiety and a composite of positive affect from the BEC were used to test the effectiveness of the manipulation within each condition. As predicted boredom increased significantly in the boredom condition (*t* [53] = -4.66, *p* < .01). There was no significant change in anger in this condition (*t* [54] = 1.35, *p* = .18); however, anxiety (*t* [54] = 3.81, *p* < .01) and positive affect (*t* [54] = 6.79, *p* < .01) decreased significantly from baseline. In the anger condition, anger increased significantly (*t* [51] = -9.81, *p* < .01). There was no significant change in anxiety (*t* [51] = -1.46, *p* = .15) but boredom (*t* [51] = 2.83, *p* < .01) and positive affect (*t* [51] = 2.78, *p* < .01) demonstrated a decreasing trend. Within the anxiety condition, anxiety increased significantly (*t* [50] = -6.51, *p* < .01). Interestingly, anger increased (*t* [50] = -4.41, *p* < .01) as well, while boredom (*t* [50] = 4.30, *p* < .01) and positive affect decreased significantly (*t* [50] = 4.07, *p* < .01) in this condition. Change in negative and positive affect from baseline to post-induction did not differ on the basis of emotional reactivity in the boredom (*p*'s >.170), anger (*p*'s > .15) or anxiety (*p*'s > .18) mood induction conditions.

A follow-up one-way ANOVA was analyzed to determine if post-induction positive affect, boredom, anger and anxiety differed between conditions. Utilizing a Tukey HSD test it was found that boredom was significantly higher in the boredom condition than in the anger (*p* < .01) and anxiety (*p* < .01) conditions but no different between the anxiety and anger conditions (*p* = .98). Similarly, anger was significantly higher in the anger condition than in the anxiety (*p* < .01) and boredom (*p* < .01) conditions. Anger was also significantly higher in the anxiety condition than in the boredom condition (*p* < .01). Anxiety was significantly higher in the anxiety condition than in the boredom (*p* < .01) and anger conditions (*p* < .01). There was no significant difference in anxiety between the anger and boredom conditions, although the anger condition had a trend towards having more anxiety (*p* = .09). There were no significant differences between the anger and boredom (*p* = .56), boredom and anxiety (*p* = .96), or anger and anxiety (*p* = .73) conditions on positive affect (see Figure 4.1 for post-induction mood scores). Results indicate that our procedure elicited the intended mood state in the boredom and anger conditions, while the anxiety condition increased the experience of anxiety as well as anger. Additionally, the degree to which this mood state was induced did not differ based on level of emotional reactivity.

Figure 4.1. *Change in ratings of anger, boredom, anxiety and positive affect from baseline to post-induction. Error bars represent +/- 2 standard errors of the mean.*

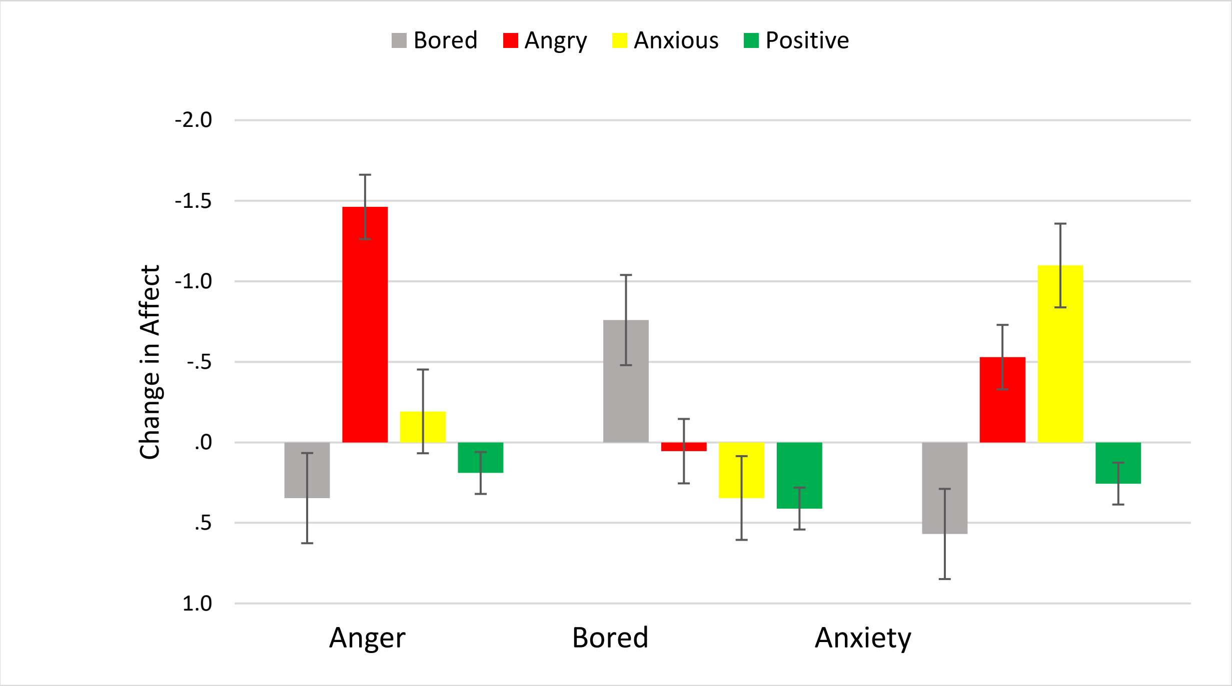
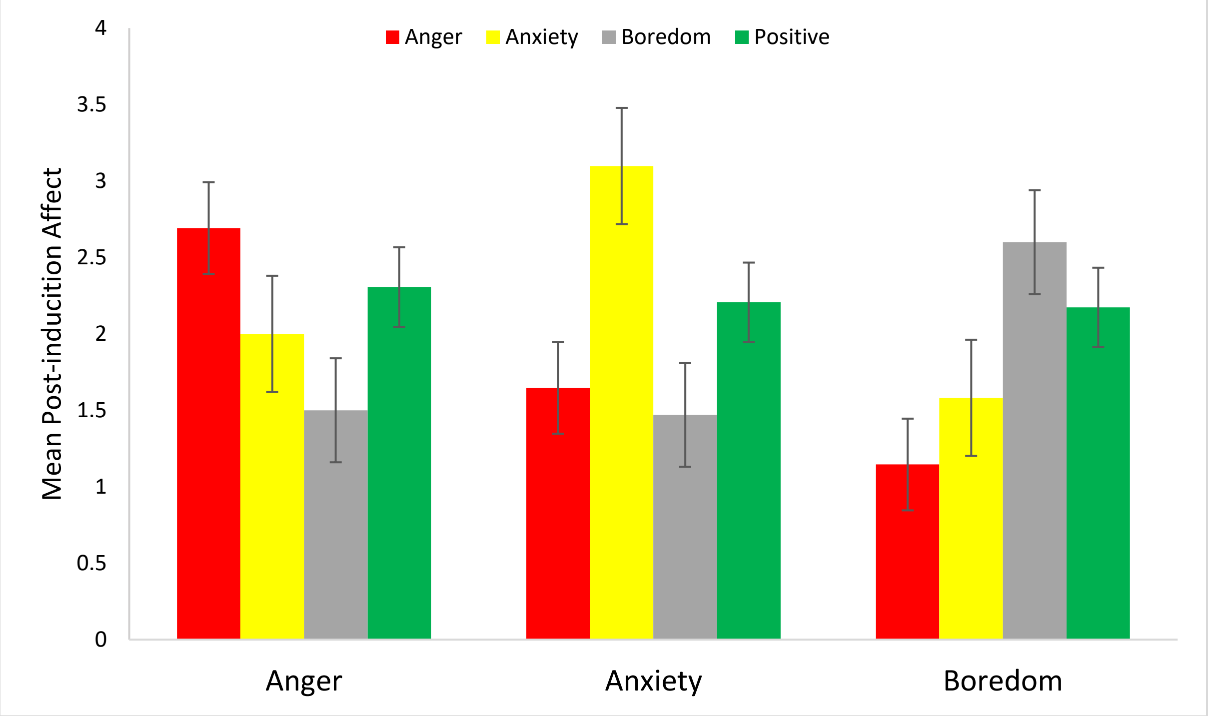


Figure 4.2. *Post-induction affect ratings of anger, anxiety, boredom and positive affect compared across anxiety, anger and boredom conditions. Error bars represent +/- 2 standard errors of the mean.*



Primary Analyses

Effect of condition on response inhibition

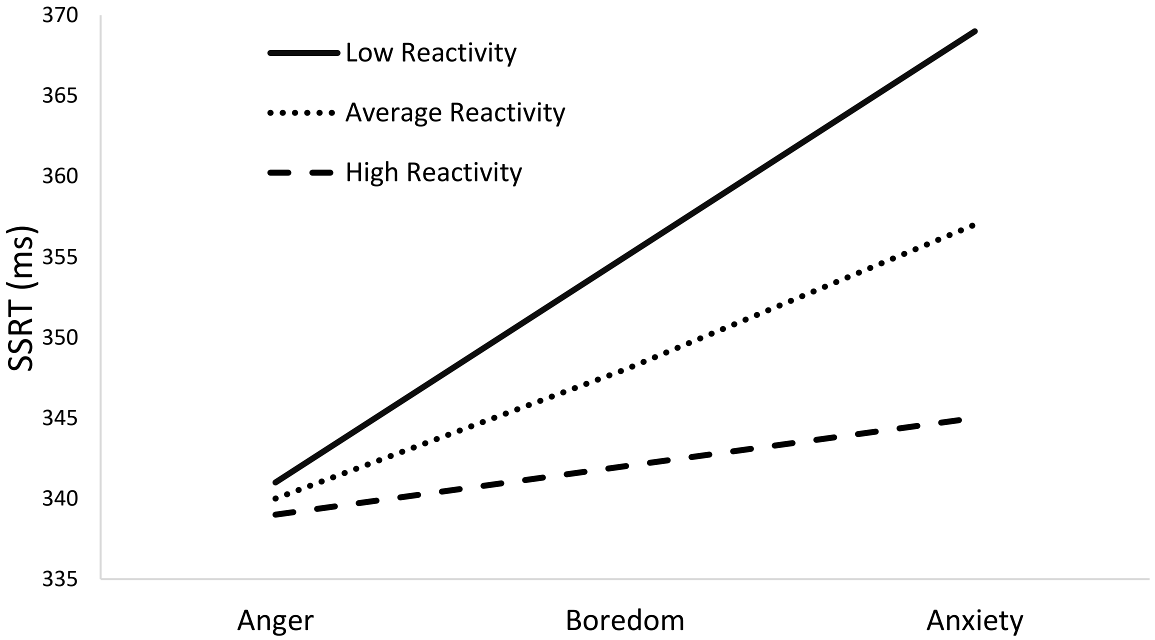
A one-way ANOVA was used to test whether performance on the Stop Signal task differed as a function of condition. A priori contrasts involved comparison of the anxiety condition to the anger condition and secondary and tertiary contrasts that compared the boredom to anger and boredom to anxiety conditions. Levene's test revealed homogeneity of variance in SSRT across conditions. Neither the difference between the anxiety and anger condition (*t* [155] = -1.68, *p* = .10) nor the differences between the boredom and anxiety conditions (*t* [155] = 1.12, *p* = .26) or boredom and anger conditions (*t* [155] = -.58, *p* = .56) were significant, although mean SSRT was slowest in the anxiety condition and fastest in the anger condition (see Table 4.1

for descriptives). Overall the effect of condition on Stop Signal performance explained 1.8% of the variance (R^2 = .02, F[1, 156] = 2.82, p = .10).

Emotional reactivity as a moderator

When emotional reactivity was added as a moderator and positive affect was included as a covariate, 6.7% of the variance in Stop Signal performance was explained by the model (R^2 = .07, F[7, 150] = 1.54, p = .16).

Figure 4.3. *Effect of negative mood condition using emotional reactivity as a moderator with positive and negative affect as covariates.*



Individual differences analysis

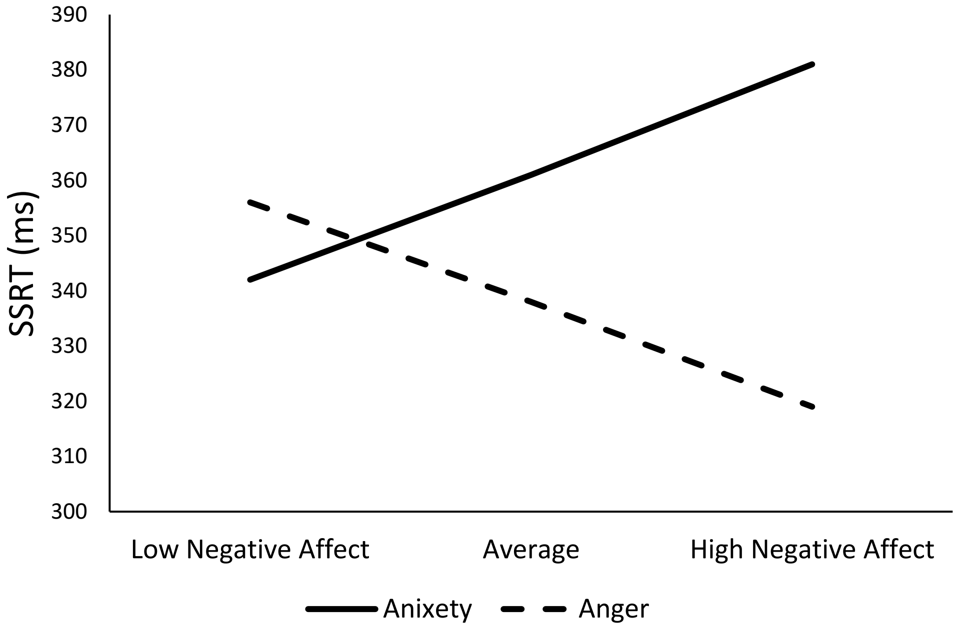
Next, we explored whether individual differences in negative affect influenced SSRT in the entire sample. Positive affect and emotional reactivity were added into the model as covariates at step one. The negative affect and dummy coded mood condition using anxiety as the reference group were added in step two and the interactions of dummy coded conditions with negative affect were entered at step three. The overall model accounted for 12.3% of the variance in SSRT ($R^2 = .12$, F [7, 150] = 3.01, $p < .01$). Positive affect and emotional reactivity did not explain a significant amount of variance at step one ($R^2 = .03$, F [2, 155] = 2.47, $p = .09$). At step two, dummy coded anger and boredom and negative affect did not add a significant amount of variance ($\Delta R^2 = .02$, ΔF [3, 152] = 1.05, $p = .37$); however, the interaction terms between dummy coded anger and boredom and negative affect added a significant amount of variance to the model at step three ($\Delta R^2 = .07$, ΔF [2, 150] = 6.20, $p < .01$). Herein, the interaction of the anger condition with negative affect was significant ($B = -45.30$, $SE = 16.04$, $t = -2.83$, $p < .01$, 95% CI [-76.89 – -13.61]) while the interaction of the boredom condition with negative affect was not ($B = 7.03$, $SE = 17.34$, $t < 1$, $p = .69$, 95% CI [-27.23 – 41.29]).[3]

Using PROCESS version 3.4 (Hayes, 2014), simple slopes for the regression of negative affect on SSRT were tested for the anxiety and anger condition. In the anger condition, increasing negative affect was associated with faster SSRTs ($B = -22.95$, $SE = 10.29$, $t = -2.23$, $p = .03$, 95% CI [-43.37 – -2.53]). An opposing pattern of negative affect on performance was evident in the anxiety condition ($B = 24.18$, $SE = 12.36$, $t = 1.96$, $p = .05$, 95% CI [-.35 – -48.70]; see Figure 4.4). These results suggest that individuals are performing significantly better in the anger condition than the anxiety condition with increasing levels of negative affect.

---

[3] Model with log-transformed negative affect: $R^2 = .13$, F [7, 150] = 3.20, p < .01.

Figure 4.4. *Effect of performance between the anger and anxiety conditions with negative affect as a predictor and positive affect and emotional reactivity as covariates.*



4.4 Discussion

This study was undertaken to examine how specific emotional states, varying in motivation, would potentially interact with emotional reactivity to influence inhibitory performance. Contrary to expectation, response inhibition was statistically comparable across the anger (high-arousal approach-motivation), anxiety (high-arousal avoidant-motivation), and boredom (low-arousal approach-motivation) conditions. While we were unable to provide a strict replication of Shields et al. (2016) between conditions, our individual differences analysis suggests that higher levels of negative affect predict performance differently between the two conditions that models the fan interaction in Shields and colleagues (2016). In this current study, those in the anger condition performed better at higher levels of negative affect while those in the anxiety condition performed worse as negative affect increased. Given our prediction that anger and anxiety should be high arousal conditions, this pattern of findings makes sense: increasing levels of negative affect may activate motivational systems (approach vs. avoidance) and have disparate effects on performance across conditions. Overall, these results provide partial support for motivational and arousal accounts regarding the relationship between emotion and EF. Avoidance motivated arousal has been considered to be more cognitive and physiologically taxing than approach motivated arousal (Roskes et. al., 2013) and thus it may be that cognitive load is higher under conditions of avoidance motivation. Conversely, it may be that approach motivation signalled through emotions such as anger might lead to a push towards task engagement that utilizes an analytic thinking style that is beneficial for tasks of response inhibition. Future research could examine this latter proposition by looking at the effects of anger on EF tasks that are proposed to be benefitted via a heuristic thinking style such as creativity. If effects divergent with tasks of creativity it would be suggestive that anger engenders an analytic thinking style whereas if effects were similar to what was found in the current study, it would be indicative that approach motivation, as opposed to the underlying thinking style, that is helpful in task performance.

An alternative mediating mechanism that could explain our pattern of results comes from the devaluation-by-inhibition hypothesis (De Vito et al., 2018). This theory suggests that negative affect is utilized in response inhibition such that to-be-inhibited stimuli are found to be devalued compared to other stimuli that are fixated on (De Vito et al., 2018; Driscoll et al., 2018; Fenske & Eastwood, 2003, Fenske & Raymond, 2006, Fenske et al., 2005; Raymond et al., 2005). Thus, it is possible that negative affect may be utilized to improve response inhibition via the Stop Signal task if this affective state is directed towards the stimulus to be inhibited (i.e., when it is approach motivated). Future research could induce angry (approach) and anxious (avoidant) mood states and observe whether those in the anger condition devalue the to-be-inhibited stimuli more than those in the anxious condition. This would provide evidence to support motivational models and the importance of negative affect in response inhibition. Additionally, future research looking at natural variations in mood could examine how individual differences in emotional reactivity or neuroticism differ in their devaluation of the to-be-inhibited stimuli. Emotionally reactive and neurotic individuals are associated with increased experience of negative affect and based on findings supporting the affective certainty and cognitive load hypotheses through natural variations in mood (Gabel & McAuley, 2018; Tamir & Robinson, 2004) it might be predicted that these individuals would devalue the to-be-inhibited stimuli more than those lower in reactivity.

Interestingly, in the current study emotional reactivity and its interaction with negative mood condition did not predict a significant amount of variance above and beyond condition alone. These results fail to support the affective certainty model (Tamir & Robinson, 2004; Tamir et al., 2002) that has been supported in previous research in our lab (Gabel & McAuley, 2018; 2020), although they are not in opposition to this model either. The pattern of results was in the expected direction and between group differences may just have a smaller effect size than we had originally predicted.

Another interesting finding regarding emotional reactivity in the current study is that change in negative affect was not related, positively or negatively, to emotional reactivity. Given that emotional reactivity is said to be related to the intensity of reactions to emotional situations it would be logical to think that emotional reactivity would be associated with a larger increase in negative affect through the mood induction. While inconsistent at a conceptual level, this finding is consistent with previous results indicating no relationship between change in negative affect and emotional reactivity after a negative mood induction (Gabel & McAuley, 2020). It is difficult to postulate why a lack of effect is present other than to suggest that perhaps emotional reactivity refers more to negative emotional persistence rather than the intensity of emotional experience.

Overall, the current study, whilst unable to provide a full replication of Shields and colleagues (2016) findings, provides some confirmatory evidence that motivational information informed by increased negative arousal is important for understanding the relationship between emotion and response inhibition. Conversely, past studies have found support for the affective certainty model through individual differences factors such as neuroticism (Tamir & Robinson, 2004) and emotional reactivity (Gabel & McAuley, 2018; 2020) which lead to diverging predictions in how emotion affects response inhibition depending on what is affectively normal at the individual level. The current study was unable to find overwhelming support for this model.

Chapter 5: General Discussion

Response inhibition is a foundational executive functioning skill, which involves withholding responses that are pre-potent yet inappropriate within a particular goal-context. To date, its relationship with emotion has been largely explored through emotional valence and existing studies have failed to find consistent support for cognitive load, mood-as-information, or motivational models. The presented research provides evidence for a model of emotion that incorporates the aforementioned models by utilizing affective certainty theory (Tamir & Robinson, 2004) which identifies that individual differences in the experience of emotion will moderate how negative affect effects response inhibition performance. Emotional reactivity is presented as an important individual differences factor that is identified by more frequent, intense and long-lasting negative mood states (Nock et al., 2008). Results generally supported the affective certainty and cognitive load models, although there is some evidence supporting the mood-as-information and motivational models as well.

Chapter 2 built upon my Masters work which found a moderating effect of emotional reactivity on the relationship between negative affect and response inhibition such that individuals lower in reactivity tended to perform worse the more negative affect they experienced and individuals higher in reactivity showed the opposite effect (Gabel & McAuley, 2018). Chapter 2 expanded upon this by inducing negative or positive mood states through a memory-based mood induction. Results supported findings from Gabel and McAuley (2018) with individuals higher in reactivity performing better with increasing negative affect and individuals lower in reactivity exhibiting an opposing pattern. Moreover, individuals higher in reactivity performed similarly across positive and negative conditions while individuals lower in reactivity performed significantly worse in the negative mood condition. The performance decrement by individuals lower in reactivity is congruous with both the affective certainty (Tamir & Robinson, 2004; Tamir et al., 2002) and cognitive load theories (Seibert & Ellis, 1991), which propose that negative moods might introduce cognitive interference that gets in the way of task performance for individuals who do not typically experience negative mood. Conversely, the facilitative effect demonstrated by individuals higher in reactivity is consistent with both the affective certainty and mood-as-information theories (Schwarz and Clore, 2003). As these individuals are generally more familiar with negative mood, negative affect does not introduce cognitive load and a more analytic information processing style which is engendered by negative affect may be utilized to improve performance. However, we did not manipulate or measure thinking style in this study and as such our explanation for those higher in reactivity accessing an analytic thinking style is speculative.

Accordingly, Chapter 3 explored how different information processing styles, analytic and heuristic, might add to our understanding of how negative affect and emotional reactivity interact to predict response inhibition. Results obtained from this study were mixed where individuals in the analytic condition did not demonstrate better performance than those in the heuristic condition. However, an interesting pattern was observed within each condition where there was a replication of the finding from Gabel and McAuley (2018) in the heuristic condition such that individuals higher in reactivity performed better with increased negative affect and individuals lower in reactivity exhibited the opposite pattern. Research has demonstrated that individuals typically experience positive mood and generally adopt a more heuristic information processing style (Diener & Diener, 1996; Gasper & Clore, 2002) and thus the replication of the interactive effect within this condition makes sense as the induction would generally be consistent with the information processing style of most individuals at baseline. Conversely, in the analytic condition individuals tended to perform better with increasing levels of negative affect regardless of emotional reactivity. Negative emotions are related to less heuristic thinking and a more analytic information processing style (Gasper & Clore, 2002; Rodriguez-Gomez et al., 2019; Smith et al., 2014) and it is plausible that negative mood in the analytic condition may have strengthened the induction to aid in response inhibition across individuals.

Chapter 4 added to this line of work by examining how different motivational systems underlying discrete negative affective states influenced response inhibition. A study by Shields and colleagues (2016) had found that approach and avoidance motivated negative emotions, anger and anxiety respectively, influenced EF performance in divergent ways such that anxiety impaired EF while anger did not. Chapter 4 aimed to replicate findings from this study while adding in the contribution of emotional reactivity to this relationship. Results were unable to replicate findings from Shields et al.'s (2016) original experiment, although degree of negative affect influenced anger and anxiety conditions in opposing ways. Increased negative affect predicted improved performance in the negative mood condition while demonstrating the opposite effect in the anxiety condition consistent with what was observed in Shields and colleagues (2016) experiment. Counter to our predictions, there was no significant effect of an interaction between emotional reactivity and negative affect condition, although trends were again in the same direction as our hypothesis.

Across the chapters presented in this dissertation is the finding that performance on the Stop Signal task is not impaired by the experience of negative affect and was in many instances improved by increasing levels of negative affect. A potential insight that might speak to why negative affect is not detrimental for those higher in reactivity, and may in fact facilitate performance under certain conditions, comes from the devaluation-by-inhibition hypothesis.

Fenske and collaborators (Fenske & Eastwood, 2003; Fenske & Raymond, 2006; Raymond et al., 2005) have posited that while emotion influences attention, attention also influences emotion. A finding that has been repeatedly demonstrated is that individuals make affective devaluations of inhibited stimuli. Support for these findings have been extended to social-emotional devaluations of trustworthiness, sexual arousal, and valence of inhibited information (De Vito et al., 2018; Driscoll et al., 2018; Fenske et al., 2005). These converging lines of evidence support the devaluation-by-inhibition hypothesis which suggests that negative affect is related to and important in inhibiting a response (De Vito et al., 2017). This lends some potential insight into the evolutionarily adaptive purpose of negative affect in the inhibition of environmental information which posits that conflict between a pre-potent response and an adaptive but novel response requires some devaluation of the pre-potent response to favour a novel response that might be adaptive given the situation (Fenske & Raymond, 2006). In other words, one must ignore a heuristic response in favor of an untrained or novel response. An emotion-focused approach to signify a need for change via statistical learning would be to devalue the to-be-inhibited stimulus until the heuristic changes to a more adaptive one. While results from this dissertation and Gabel & McAuley (2018) are not incongruous with this account, there is currently no known research supporting this conjecture. Future research could examine the devaluation-by-inhibition hypothesis jointly with mood and emotion reactivity research such that differences in degree of devaluation of the to-be-inhibited stimulus are observed across emotional reactivity and experience of negative affect.

The studies presented in this dissertation provide evidence that individuals higher in reactivity are typically better able to utilize negative affect effectively in adapting to a novel task involving response inhibition. Consistent with Tamir and colleagues (Tamir & Robinson, 2004;

Tamir et al., 2002) affective certainty model, it is likely that high reactive individuals are not influenced by negative affect in a detrimental way because negative moods are trait-consistent for them. This trait-consistency has the potential to alleviate cognitive load that might come in the form of health promoting but task irrelevant emotion regulation (Curci et al., 2013; John & Gross, 2004) or ambivalence of attentional deployment (Nelson et al., 2015). Because they might engage less in active emotion regulatory techniques or utilize less ambivalent strategies for attentional deployment, individuals higher in reactivity might be able to utilize analytic thinking provided through negative affect and devalue the pre-potent response more effectively than low reactive individuals leading to improved response inhibition. A major limitation of the current line of research is that attentional strategies and emotion regulation were not assessed. Future research should focus on elucidating the relationship between the utilization of emotion regulation and attentional strategies and emotional reactivity during cognitive tasks.

Relatedly, another limitation of the work presented in this dissertation is that the chosen conceptualization of emotional reactivity refers specifically to negative emotional reactivity and is not considered in relation to emotion regulation or distress tolerance. More recent conceptualizations of emotional reactivity have suggested that facets of both negative and positive emotional reactivity can be measured and that these two facets share a mild negative relationship (Becerra & Campitelli, 2013; Becerra et al., 2019). Future research might also consider positive emotional reactivity as a pertinent individual differences factor that might moderate the relationship between affect and response inhibition. Additionally, negative emotional reactivity has been related to emotion dysregulation and specifically to perceived limitations in implementing effective emotion regulation strategies (Becerra et al., 2019). As the particular emotion regulation strategies utilized by high reactive individuals remain unspecified, it would be important for future research to determine how individuals higher in negative emotional reactivity differ in their emotion regulation strategy use. It would be particularly interesting to explore if there are differences in long-term (e.g., cognitive reappraisal) vs. short-term effectiveness (e.g., expressive suppression) of emotion regulation strategy use and how these differences affect cognitive load and response inhibition performance. Furthermore, recent research by Bruns and colleagues (Bruns et al., 2019) has provided evidence that emotional reactivity is negatively related to distress tolerance above and beyond the experience of negative affect. Distress tolerance refers to an individual's ability to withstand unpleasant emotional experiences. It is similar to negative emotional reactivity in that it is related to emotional distress and distinct in that it includes aspects of emotional acceptance and regulation of negative affect (Simons & Gaher, 2005). Accordingly, distress tolerance incorporates aspects of emotional reactivity and emotion regulation and future research might consider utilizing this construct as a further individual differences factor influencing the relationship between affect and response inhibition.

Additionally, it is important to note that psychopathology has been shown to hinder performance on cognitive tasks (Epp et al., 2012, Joormann et al., 2011) and given that emotional reactivity is highly related to psychopathology (Thake & Zelenski, 2013; Wei et al., 2005) it is important to address how the current line of research might replicate in a clinical sample. It is plausible that our sample might represent an 'optimal zone' of reactivity that is not indicative of psychopathology and as such increased negative affect and arousal might be utilized effectively within this population. Given our model of emotion it might be expected that a clinical sample would be especially hindered by depression which lowers arousal making it more difficult for individuals to engage in the task effectively (Grahek et al., 2018). As mentioned, research has also demonstrated that emotion dysregulation such as rumination which is commonly persistent amongst depressed individuals also presents cognitive load which will further interfere with tasks of response inhibition (Curci et al., 2013; Joormann et al., 2011).

Conversely, it can be seen how extremely high levels of arousal involved in emotions such as terror, rage or euphoria would also lead to task interference. Our results for reactivity and affective intensity make sense in the context of naturally occurring and induced mood with mild to moderate arousal. However, one might expect that moods high in arousal would result in emotional flooding and have the opposite effect of what we observed. In the current samples, inductions did not seem to affect high reactive individuals to a greater degree than low reactive individuals and accordingly, it is likely that the limited mood inductions that can be achieved in the context of a lab experiment are not representative of real-life situations where much higher arousal might be present.

Although laboratory experiments do not perfectly reflect conditions of everyday life, the task demands of the Stop Signal task – to stop a response that is naturally pre-potent – are reflective of many real-life situations. For example, running from first base to second base when the ball is hit (i.e., the go stimulus) before knowing whether the ball will be caught (i.e., the stop signal). Testing response inhibition in a lab-setting where the consequences of failure to inhibit might be much less than in the natural environment might not draw attention to failures of response inhibition. Thus, limitations to the ecological validity of the Stop Signal paradigm are most evident in underrepresenting consequences to failures of response inhibition.

Overall, the work presented in this dissertation contributes a more nuanced understanding of how emotional valence, motivation and related information processing styles relate to response inhibition. Emotional reactivity emerged as a key component, speaking for what is emotionally trait-consistent at the individual level. This construct was a significant moderator of the relationship between negative affect and response inhibition performance which supported the affective certainty and cognitive load hypotheses. When information processing was manipulated to be more analytic and when underlying motivation was manipulated to be more approach-oriented this moderating relationship was unobservable and the primary predictor of improved performance was increased negative affect. These results suggest that negative affect is quite likely essential for response inhibition; however, the degree to which negative affect allows for effective inhibition might depend on how we typically experience negative emotions and what motivational information provided through negative emotions tell us.

References

Albert, J., López-Martín, S., & Carretié, L. (2010). Emotional context modulates response inhibition: Neural and behavioral data. *Neuroimage*, *49*(1), 914-921.

Alexander, J. K., Hillier, A., Smith, R. M., Tivarus, M. E., & Beversdorf, D. Q. (2007). Beta-adrenergic modulation of cognitive flexibility during stress. *Journal of Cognitive Neuroscience*, *19*(3), 468-478.

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review*, *16*(1), 17-42.

Augustine, A. A., Larsen, R. J., & Lee, H. (2013). *Affective personality traits and cognition: Interactions between extraversion/neuroticism, affect, and cognition.* In M. D. Robinson, E. Watkins, & E. Harmon-Jones (Eds.), *Handbook of cognition and emotion* (p. 312–328). Guilford Press.

Baddeley, A. (1992). Working memory. *Science*, *255*(5044), 556-559.

Banich, M. T. (2009). Executive function: The search for an integrated account. *Current Directions in Psychological Science*, *18*(2), 89-94.

Bar, M. (2009). A cognitive neuroscience hypothesis of mood and depression. *Trends in Cognitive Sciences*, *13*(11), 456-463.

Baer, R. A., & Sauer, S. E. (2011). Relationships between depressive rumination, anger rumination, and borderline personality features. *Personality Disorders: Theory, Research, and Treatment*, *2*(2), 142-150.

Barrett, L. F., & Bar, M. (2009). See it with feeling: Affective predictions during object perception. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1521), 1325-1334.

Becerra, R., & Campitelli, G. (2013). Emotional reactivity: Critical analysis and proposal of a new scale. *International Journal of Applied Psychology*, *3*(6), 161-168.

Becerra, R., Preece, D., Campitelli, G., & Scott-Pillow, G. (2019). The assessment of emotional reactivity across negative and positive emotions: Development and validation of the Perth Emotional Reactivity Scale (PERS). *Assessment*, *26*(5), 867-879.

Bell, M. A., & Fox, N. A. (1992). The relations between frontal brain electrical activity and cognitive development during infancy. *Child Development*, *63*(5), 1142-1163.

Bench, S. W., & Lench, H. C. (2013). On the function of boredom. *Behavioral sciences*, *3*(3), 459-472.

Bodenhausen, G. V., Sheppard, L. A., & Kramer, G. P. (1994). Negative affect and social judgment: The differential impact of anger and sadness. *European Journal of Social Psychology*, *24*(1), 45-62.

Bohner, G., Chaiken, S., & Hunyadi, P. (1994). The role of mood and message ambiguity in the interplay of heuristic and systematic processing. *European Journal of Social Psychology*, *24*(1), 207-221.

Bossuyt, E., Moors, A., & De Houwer, J. (2014). On angry approach and fearful avoidance: The goal-dependent nature of emotional approach and avoidance tendencies. *Journal of Experimental Social Psychology*, *50*, 118-124.

Boyes, M. E., Clarke, P. J., & Hasking, P. A. (2020). Relationships between dispositional and experimentally elicited emotional reactivity, intensity, and perseveration. *Personality and Individual Differences*, *152*, 109573.

Brinker, J. K., Campisi, M., Gibbs, L., & Izzard, R. (2013). Rumination, mood and cognitive performance. *Psychology*, *4*(03), 224-231.

Bruns, K. M., O'Bryan, E. M., & McLeish, A. C. (2019). An examination of the association between emotion reactivity and distress tolerance among college students. *The Journal of Nervous and Mental Disease, 207*(6), 429-432.

Bunce, D., Handley, R., & Gaines Jr, S. O. (2008). Depression, anxiety, and within-person variability in adults aged 18 to 85 years. *Psychology and Aging, 23*(4), 848-858.

Burgess, P. W. (2004). Theory and methodology in executive function research. In *Methodology of frontal and executive function* (pp. 87-121). Routledge.

Burgoon, E. M., Henderson, M. D., & Markman, A. B. (2013). There are many ways to see the forest for the trees: A tour guide for abstraction. *Perspectives on Psychological Science, 8*(5), 501-520.

Cannon, W. B. (1929). Organization for physiological homeostasis. *Physiological reviews, 9*(3), 399-431.

Charbonneau, A. M., Mezulis, A. H., & Hyde, J. S. (2009). Stress and emotional reactivity as explanations for gender differences in adolescents' depressive symptoms. *Journal of Youth and Adolescence, 38*(8), 1050-1058.

Charness, G., Gneezy, U., & Kuhn, M. A. (2012). Experimental methods: Between-subject and within-subject design. *Journal of Economic Behavior & Organization, 81*(1), 1-8.

Clore, G. L., & Huntsinger, J. R. (2007). How emotions inform judgment and regulate thought. *Trends in Cognitive Sciences, 11*(9), 393-399.

Compas, B. E., Connor-Smith, J., & Jaser, S. S. (2004). Temperament, stress reactivity, and coping: Implications for depression in childhood and adolescence. *Journal of Clinical Child and Adolescent Psychology, 33*(1), 21-31.

Corr, P. J. (2004). Reinforcement sensitivity theory and personality. *Neuroscience & Biobehavioral Reviews*, *28*(3), 317-332.

Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (Eds.). (1992). *Optimal experience: Psychological studies of flow in consciousness*. Cambridge University Press.

Curci, A., Lanciano, T., Soleti, E., & Rimé, B. (2013). Negative emotional experiences arouse rumination and affect working memory capacity. *Emotion*, *13*(5), 867-880.

De Lissnyder, E., Koster, E. H., & De Raedt, R. (2012). Emotional interference in working memory is related to rumination. *Cognitive Therapy and Research, 36*(4), 348-357.

De Vito, D., Al-Aidroos, N., & Fenske, M. J. (2017). Neural evidence that inhibition is linked to the affective devaluation of distractors that match the contents of working memory. *Neuropsychologia*, *99*, 259-269.

De Vito, D., Ferrey, A. E., Fenske, M. J., & Al-Aidroos, N. (2018). Cognitive-behavioral and electrophysiological evidence of the affective consequences of ignoring stimulus representations in working memory. *Cognitive, Affective, & Behavioral Neuroscience, 18*(3), 460-475.

Delgado, M. R., Nearing, K. I., LeDoux, J. E., & Phelps, E. A. (2008). Neural circuitry underlying the regulation of conditioned fear and its relation to extinction. *Neuron, 59*(5), 829-838.

Diener, E., & Diener, C. (1996). Most people are happy. *Psychological science*, *7*(3), 181-185.

Diener, E., Larsen, R. J., Levine, S., & Emmons, R. A. (1985). Intensity and frequency: Dimensions underlying positive and negative affect. *Journal of Personality and Social Psychology*, *48*(5), 1253-1265.

Dijkstra, K. A., van der Pligt, J., & van Kleef, G. A. (2017). Fit between decision mode and processing style predicts subjective value of chosen alternatives. *European Journal of Social Psychology*, *47*(1), 72-81.

Drabek, T. E. (2012). *Human system responses to disaster: An inventory of sociological findings*. Springer Science & Business Media.

Driscoll, R. L., De Launay, K. Q., & Fenske, M. J. (2018). Less approach, more avoidance: Response inhibition has motivational consequences for sexual stimuli that reflect changes in affective value not a lingering global brake on behavior. *Psychonomic Bulletin & Review*, *25*(1), 463-471.

Eich, E., Ng, J. T., Macaulay, D. P. A. D., Percy, A. D., & Grebneva, I. (2007). Combining music with thought to change mood. In J. A. Coan & J. J. Allen (Eds.), *Handbook of emotion elicitation and assessment* (pp. 124–136). New York, NY: Oxford University Press.

Elliot, A. J., Eder, A. B., & Harmon-Jones, E. (2013). Approach–avoidance motivation and emotion: Convergence and divergence. *Emotion Review*, *5*(3), 308-311.

Epp, A. M., Dobson, K. S., Dozois, D. J., & Frewen, P. A. (2012). A systematic meta-analysis of the Stroop task in depression. *Clinical Psychology Review*, *32*(4), 316-328.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

Fenske, M. J., & Eastwood, J. D. (2003). Modulation of focused attention by faces expressing emotion: evidence from flanker tasks. *Emotion*, *3*(4), 327-343.

Fenske, M. J., & Raymond, J. E. (2006). Affective influences of selective attention. *Current Directions in Psychological Science*, *15*(6), 312-316.

Fenske, M. J., Raymond, J. E., Kessler, K., Westoby, N., & Tipper, S. P. (2005). Attentional inhibition has social-emotional consequences for unfamiliar faces. *Psychological Science*, *16*(10), 753-758.

Forgas, J. P., & Koch, A. S. (2013). *Mood effects on cognition.* In M. D. Robinson, E. Watkins, & E. Harmon-Jones (Eds.), *Handbook of cognition and emotion* (p. 231–251). Guilford Press.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist*, *56*(3), 218-226.

Fredrickson, B. L., & Branigan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition & Emotion*, *19*(3), 313-332.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: a latent-variable analysis. *Journal of experimental psychology: General*, *133*(1), 101-135.

Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex*, *86*, 186-204.

Friedman, N. P., Miyake, A., Robinson, J. L., & Hewitt, J. K. (2011). Developmental trajectories in toddlers' self-restraint predict individual differences in executive functions 14 years later: A behavioral genetic analysis. *Developmental Psychology, 47*(5), 1410-1430.

Gabel, M. S., & McAuley, T. (2018). Does mood help or hinder executive functions? Reactivity may be the key. *Personality and Individual Differences, 128*, 94-99.

Gabel, M. S., & McAuley, T. (2020). React to act: Negative mood, response inhibition, and the moderating role of emotional reactivity. *Motivation and Emotion*, *44*(6), 862-869.

Gable, P. A., & Harmon-Jones, E. (2010a). Late positive potential to appetitive stimuli and local attentional bias. *Emotion*, *10*(3), 441-446.

Gable, P., & Harmon-Jones, E. (2010b). The blues broaden, but the nasty narrows: Attentional consequences of negative affects low and high in motivational intensity. *Psychological Science*, *21*(2), 211-215.

Gable, P. A., Poole, B. D., & Harmon-Jones, E. (2015). Anger perceptually and conceptually narrows cognitive scope. *Journal of Personality and Social Psychology*, *109*(1), 163-174.

Ganguli, M., Snitz, B., Bilt, J. V., & Chang, C. C. H. (2009). How much do depressive symptoms affect cognition at the population level? The Monongahela–Youghiogheny Healthy Aging Team (MYHAT) study. *International Journal of Geriatric Psychiatry*, *24*(11), 1277-1284.

Gasper, K., & Clore, G. L. (2002). Attending to the big picture: Mood and global versus local processing of visual information. *Psychological Science*, *13*(1), 34-40.

Gasper, K., & Middlewood, B. L. (2014). Approaching novel thoughts: Understanding why elation and boredom promote associative thought more than distress and relaxation. *Journal of Experimental Social Psychology*, *52*, 50-57.

Gasper, K., & Zawadzki, M. J. (2013). Want information? How mood and performance perceptions alter the perceived value of information and influence information-seeking behaviors. *Motivation and Emotion*, *37*(2), 308-322.

Goetz, T., Frenzel, A. C., Hall, N. C., Nett, U. E., Pekrun, R., & Lipnevich, A. A. (2014). Types of boredom: An experience sampling approach. *Motivation and Emotion*, *38*(3), 401-419.

Goldstein, S., Naglieri, J. A., Princiotta, D., & Otero, T. M. (2014). Introduction: A history of executive functioning as a theoretical and clinical construct. In *Handbook of executive functioning* (pp. 3-12). Springer.

Grahek, I., Everaert, J., Krebs, R. M., & Koster, E. H. (2018). Cognitive control in depression: Toward clinical models informed by cognitive neuroscience. *Clinical Psychological Science, 6(*4), 464-480.

Gramszlo, C., & Woodruff-Borden, J. (2015). Emotional reactivity and executive control: A pathway of risk for the development of childhood worry. *Journal of Anxiety Disorders*, *35*, 35-41.

Gray, J. A. (1970). The psychophysiological basis of introversion-extraversion. *Behaviour Research and Therapy*, *8*(3), 249-266.

Gary, J. A., & Mc Naughton, N. (2000). The neuropsychology of anxiety. *Oxford Psychology Series*, *33*(4).

Harmon-Jones, E. (2003). Anger and the behavioral approach system. *Personality and Individual Differences*, *35*(5), 995-1005.

Harmon-Jones, E., Harmon-Jones, C., Abramson, L., & Peterson, C. K. (2009). PANAS positive activation is associated with anger. *Emotion*, *9*(2), 183–196.

Harmon-Jones, E., Harmon-Jones, C., Amodio, D. M., & Gable, P. A. (2011). Attitudes toward emotions. *Journal of Personality and Social Psychology*, *101*(6), 1332-1350.

Harmon-Jones, E., Harmon-Jones, C., & Price, T. F. (2013). What is approach motivation?. *Emotion Review*, *5*(3), 291-295.

Harms, M. B., Zayas, V., Meltzoff, A. N., & Carlson, S. M. (2014). Stability of executive function and predictions to adaptive behavior from middle childhood to pre-adolescence. *Frontiers in Psychology*, *5*, 331.

Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York: Guilford.

Howland, M., Armeli, S., Feinn, R., & Tennen, H. (2017). Daily emotional stress reactivity in emerging adulthood: temporal stability and its predictors. *Anxiety, Stress, & Coping*, *30*(2), 121-132.

Huizinga, M., Dolan, C. V., & van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologia*, *44*(11), 2017-2036.

Huntsinger, J. R., Clore, G. L., & Bar-Anan, Y. (2010). Mood and global–local focus: Priming a local focus reverses the link between mood and global–local processing. *Emotion*, *10*(5), 722-726.

Huntsinger, J. R., Isbell, L. M., & Clore, G. L. (2014). The affective control of thought: Malleable, not fixed. *Psychological Review*, *121*(4), 600-618.

Isbell, L. M., Burns, K. C., & Haar, T. (2005). The role of affect on the search for global and specific target information. *Social Cognition*, *23*(6), 529-552.

Isbell, L. M., Lair, E. C., & Rovenpor, D. R. (2013). Affect-as-information about processing styles: A cognitive malleability approach. *Social and Personality Psychology Compass*, *7*(2), 93-114.

Isbell, L. M., Rovenpor, D. R., & Lair, E. C. (2016). The impact of negative emotions on self-concept abstraction depends on accessible information processing styles. *Emotion*, *16*(7), 1040-1049.

Isen, A. M. (1999). On the relationship between affect and creative problem solving. (pp 3-17) *Affect, creative experience, and psychological adjustment*.

Isen, A. M. (2000). Some perspectives on positive affect and self-regulation. *Psychological Inquiry, 11*(3), 184-187.

Ji, L. J., Yap, S., Best, M. W., & McGeorge, K. (2019). Global processing makes people happier than local processing. *Frontiers in Psychology, 10*, 670.

John, O. P., & Gross, J. J. (2004). Healthy and unhealthy emotion regulation: Personality processes, individual differences, and life span development. *Journal of Personality*, *72*(6), 1301-1334.

Johnson, M. H. (2001). Functional brain development in humans. Nature Reviews *Neuroscience, 2*(7), 475-483.

Johnson, M. H. (2003). Development of human brain functions. *Biological Psychiatry*, *54*(12), 1312-1316.

Joormann, J., Levens, S. M., & Gotlib, I. H. (2011). Sticky thoughts: Depression and rumination are associated with difficulties manipulating emotional material in working memory. *Psychological Science, 22*(8), 979-983.

Jurado, M. B., & Rosselli, M. (2007). The elusive nature of executive functions: a review of our current understanding. *Neuropsychology Review, 17*(3), 213-233.

Kahneman, D. (2011). *Thinking, fast and slow*. Macmillan.

Kalanthroff, E., Cohen, N., & Henik, A. (2013). Stop feeling: Inhibition of emotional interference following stop-signal trials. *Frontiers in Human Neuroscience, 7,* 78.

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: A latent-variable approach to verbal and visuospatial memory span and reasoning. *Journal of Experimental Psychology: General, 133*(2), 189–217.

Kimchi, R. (1992). Primacy of wholistic processing and global/local paradigm: A critical review. *Psychological Bulletin*, *112*(1), 24-38.

Klauer, K. C., & Singmann, H. (2015). Does global and local vision have an impact on creative and analytic thought? Two failed replications. PloS one, 10(10).

Koechlin, E. (2016). Prefrontal executive function and adaptive behavior in complex environments. *Current Opinion in Neurobiology*, *37*, 1-6.

Koster, E. H., De Lissnyder, E., & De Raedt, R. (2013). Rumination is characterized by valence-specific impairments in switching of attention. *Acta Psychologica*, *144*(3), 563-570.

Koster, E. H., De Raedt, R., Goeleven, E., Franck, E., & Crombez, G. (2005). Mood-congruent attentional bias in dysphoria: maintained attention to and impaired disengagement from negative information. *Emotion, 5*(4), 446-455.

Krypotos, A. M., Arnaudova, I., Effting, M., Kindt, M., & Beckers, T. (2015). Effects of approach-avoidance training on the extinction and return of fear responses. *PloS One*, *10*(7).

Larsen, R. J. (2000). Toward a science of mood regulation. *Psychological Inquiry*, *11*(3), 129-141.

Larsen, R. J., & Ketelaar, T. (1991). Personality and susceptibility to positive and negative emotional states. *Journal of Personality and Social Psychology*, *61*(1), 132–140.

Lench, H. C., Lench, H., & Ryan. (2018). *Function of Emotions*. (pp. 141-165) Springer.

Logan, G. D., Cowan, W. B., & Davis, K. A. (1984). On the ability to inhibit simple and choice reaction time responses: a model and a method. *Journal of Experimental Psychology: Human Perception and Performance*, *10*(2), 276-291.

Lyubomirsky, S., Kasri, F. & Zehm, K. (2003) Dysphoric rumination impairs concentration on academic tasks. *Cognitive Therapy and Research*, *27***,** 309–330.

Mac Giollabhui, N., Swistun, D., Murray, S., Moriarity, D. P., Kautz, M. M., Ellman, L. M., Olino, T. M., Coe, C. L., Abramson, L. Y. & Alloy, L. B. (2020). Executive dysfunction in depression in adolescence: The role of inflammation and higher body mass. *Psychological Medicine*, *50*(4), 683-691.

Mackie, D. M., Asuncion, A. G., & Rosselli, F. (1992). The impact of affective states on persuasion processes. *Review of personality and social psychology*, *14*, 247-270.

Mackie, D. M., & Worth, L. T. (1989). Differential recall of subcategory information about in-group and out-group members. *Personality and Social Psychology Bulletin*, *15*(3), 401-413.

Macrae, C. N., & Lewis, H. L. (2002). Do I know you? Processing orientation and face recognition. *Psychological Science*, *13*(2), 194-196.

Majima, Y. (2015). The Effect of Induced Processing Orientation on a Holistic-Analytic Thinking Task. In EAPCogSci.

Martin, E. A., & Kerns, J. G. (2011). The influence of positive mood on different aspects of cognitive control. *Cognition and Emotion*, *25*(2), 265-279.

McKasy, M. (2020). A discrete emotion with discrete effects: Effects of anger on depth of information processing. *Cognitive Processing*, 1-19.

McMillan, K. A., & Asmundson, G. J. (2016). PTSD, social anxiety disorder, and trauma: An examination of the influence of trauma type on comorbidity using a nationally representative sample. *Psychiatry Research, 246*, 561-567.

McNaughton, N., & Gray, J. A. (2000). Anxiolytic action on the behavioural inhibition system implies multiple types of arousal contribute to anxiety. *Journal of Affective Disorders*, *61*(3), 161-176.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*(1), 167-202.

Mitchell, R. L., & Phillips, L. H. (2007). The psychological, neurochemical and functional neuroanatomical mediators of the effects of positive and negative mood on executive functions. *Neuropsychologia, 45*(4), 617-629.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science*, *21*(1), 8-14.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49-100.

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences*, *7*(3), 134-140.

Moons, W. G., & Shields, G. S. (2015). Anxiety, not anger, induces inflammatory activity: An avoidance/approach model of immune system activation. *Emotion*, *15*(4), 463-476.

Munakata, Y., Snyder, H. R., & Chatham, C. H. (2012). Developing cognitive control: Three key transitions. *Current Directions in Psychological Science, 21*(2), 71-77.

Mundy, M. E. (2014). Testing day: The effects of processing bias induced by Navon stimuli on the strength of the Müller-Lyer illusion. *Advances in cognitive psychology, 10*(1), 9-14.

Murray, B. D., Holland, A. C., & Kensinger, E. A. (2013). *Episodic memory and emotion.* In M. D. Robinson, E. Watkins, & E. Harmon-Jones (Eds.), *Handbook of cognition and emotion* (pp. 156–175). Guilford Press.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology, 9*(3), 353–383.

Nelson, A. L., Purdon, C., Quigley, L., Carriere, J., & Smilek, D. (2015). Distinguishing the roles of trait and state anxiety on the nature of anxiety-related attentional biases to threat using a free viewing eye movement paradigm. *Cognition and Emotion, 29*(3), 504-526.

Nolen-Hoeksema, S. (1991). Responses to depression and their effects on the duration of depressive episodes. *Journal of Abnormal Psychology, 100,* 569–582.

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on psychological science, 3*(5), 400-424.

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin, 126*(2), 220-246.

Nock, M. K., Wedig, M. M., Holmberg, E. B., & Hooley, J. M. (2008). The emotion reactivity scale: Development, evaluation, and relation to self-injurious thoughts and behaviors. *Behavior Therapy, 39*(2), 107-116.

Oliva, A., & Torralba, A. (2006). Building the gist of a scene: The role of global image features in recognition. *Progress in Brain Research*, *155*, 23-36.

Olofsson, M. E., Wurm, M., & Boersma, K. (2016). Do responses to positive affect influence mood reactivity? Exploring cognitive response styles through a mood induction procedure. *Nordic Psychology*, *68*(4), 220-232.

Omer, H., & Alon, N. (1994). The continuity principle: A unified approach to disaster and trauma. *American Journal of Community Psychology*, *22*(2), 273-287.

Padmala, S., Bauer, A., & Pessoa, L. (2011). Negative emotion impairs conflict-driven executive control. *Frontiers in Psychology*, *2*, 192.

Park, J., & Banaji, M. R. (2000). Mood and heuristics: the influence of happy and sad states on sensitivity and bias in stereotyping. *Journal of Personality and Social Psychology*, *78*(6), 1005-1023.

Pavlov, I. P. (1927). Conditioned reflexes: an investigation of the physiological activity of the cerebral cortex. *Oxford University Press*.

Perfect, T. J., Dennis, I., & Snell, A. (2007). The effects of local and global processing orientation on eyewitness identification performance. *Memory*, *15*(7), 784-798.

Pessoa, L. (2009). How do emotion and motivation direct executive control?. *Trends in Cognitive Sciences*, *13*(4), 160-166.

Pessoa, L., Padmala, S., Kenzer, A., & Bauer, A. (2012). Interactions between cognition and emotion during response inhibition. *Emotion*, *12*(1), 192-197.

Pine, D. S., Cohen, P., & Brook, J. S. (2001). Emotional reactivity and risk for psychopathology among adolescents. *CNS Spectrums*, *6*(1), 27-35.

Pugliese, C. E., Anthony, L., Strang, J. F., Dudley, K., Wallace, G. L., & Kenworthy, L. (2015). Increasing adaptive behavior skill deficits from childhood to adolescence in autism spectrum disorder: Role of executive function. *Journal of Autism and Developmental Disorders, 45*(6), 1579-1587.

Quigley, L., Nelson, A. L., Carriere, J., Smilek, D., & Purdon, C. (2012). The effects of trait and state anxiety on attention to emotional images: An eye-tracking study. *Cognition & Emotion, 26*(8), 1390-1411.

Raymond, J. E., Fenske, M. J., & Westoby, N. (2005). Emotional devaluation of distracting patterns and faces: A consequence of attentional inhibition during visual search?. *Journal of Experimental Psychology: Human Perception and Performance, 31*(6), 1404-1415.

Ripper, C. A., Boyes, M. E., Clarke, P. J., & Hasking, P. A. (2018). Emotional reactivity, intensity, and perseveration: Independent dimensions of trait affect and associations with depression, anxiety, and stress symptoms. *Personality and Individual Differences*, *121*, 93-99.

Rock, P. L., Roiser, J. P., Riedel, W. J., & Blackwell, A. D. (2014). Cognitive impairment in depression: A systematic review and meta-analysis. *Psychological Medicine*, *44*(10), 2029-2040.

Rodríguez-Gómez, P., Pozo, M. Á., Hinojosa, J. A., & Moreno, E. M. (2019). Please be logical, I am in a bad mood: An electrophysiological study of mood effects on reasoning. *Neuropsychologia*, *127*, 19-28.

Roskes, M., Elliot, A. J., Nijstad, B. A., & De Dreu, C. K. (2013). Time pressure undermines performance more under avoidance than approach motivation. *Personality and Social Psychology Bulletin, 39*(6), 803-813.

Rowe, G., Hirsh, J. B., & Anderson, A. K. (2007). Positive affect increases the breadth of attentional selection. *Proceedings of the National Academy of Sciences*, *104*(1), 383-388.

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology, 39*(6), 1161-1178.

Russell, J. A., & Barrett, L. F. (1999). Core affect, prototypical emotional episodes, and other things called emotion: dissecting the elephant. *Journal of Personality and Social Psychology, 76*(5), 805-819.

Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychological Review*, *110*(1), 145-172.

Sacchi, S., Riva, P., & Aceto, A. (2016). Myopic about climate change: Cognitive style, psychological distance, and environmentalism. *Journal of Experimental Social Psychology*, *65*, 68-73.

Schwarz, N., & Clore, G. L. (1983). Mood, misattribution, and judgments of well-being: Informative and directive functions of affective states. *Journal of Personality and Social Psychology*, *45*(3), 513-523.

Schwarz, N., & Clore, G. L. (2003). Mood as information: 20 years later. *Psychological Inquiry*, *14*(3-4), 296-303.

Schulz, K. P., Fan, J., Magidina, O., Marks, D. J., Hahn, B., & Halperin, J. M. (2007). Does the emotional go/no-go task really measure behavioral inhibition? Convergence with measures on a non-emotional analog. *Archives of Clinical Neuropsychology*, *22*(2), 151-160.

Seibert, P. S., & Ellis, H. C. (1991). Irrelevant thoughts, emotional mood states, and cognitive task performance. *Memory & Cognition*, *19*(5), 507-513.

Shields, G. S., Moons, W. G., Tewell, C. A., & Yonelinas, A. P. (2016). The effect of negative affect on cognition: Anxiety, not anger, impairs executive function. *Emotion, 16*(6), 792-797.

Silvers, J. A., McRae, K., Gabrieli, J. D., Gross, J. J., Remy, K. A., & Ochsner, K. N. (2012). Age-related differences in emotional reactivity, regulation, and rejection sensitivity in adolescence. *Emotion*, *12*(6), 1235-1247.

Simons, J. S., & Gaher, R. M. (2005). The Distress Tolerance Scale: Development and validation of a self-report measure. *Motivation and Emotion*, *29*(2), 83-102.

Skinner, B. F. (1935). Two types of conditioned reflex and a pseudo type. *The Journal of General Psychology, 12*(1), 66-77.

Skinner, E. A., & Zimmer-Gembeck, M. J. (2007). The development of coping. *Annual Review of Psychology, 58*, 119-144.

Smith, K. W., Balkwill, L. L., Vartanian, O., & Goel, V. (2015). Syllogisms delivered in an angry voice lead to improved performance and engagement of a different neural system compared to neutral voice. *Frontiers in Human Neuroscience, 9*, 273.

Snyder, H. R. (2013). Major depressive disorder is associated with broad impairments on neuropsychological measures of executive function: a meta-analysis and review. *Psychological Bulletin, 139*(1), 81.

Srinivasan, N., & Hanif, A. (2010). Global-happy and local-sad: Perceptual processing affects emotion identification. *Cognition and Emotion, 24*(6), 1062-1069.

Ståhl, T., Van Laar, C., & Ellemers, N. (2012). The role of prevention focus under stereotype threat: Initial cognitive mobilization is followed by depletion. *Journal of Personality and Social Psychology*, *102*(6), 1239-1251.

Stafford, L. D., Ng, W., Moore, R. A., & Bard, K. A. (2010). Bolder, happier, smarter: The role of extraversion in positive mood and cognition. *Personality and Individual Differences*, *48*(7), 827-832.

Sukhodolsky, D. G., Golub, A., & Cromwell, E. N. (2001). Development and validation of the anger rumination scale. *Personality and Individual Differences*, *31*(5), 689-700.

Tamir, M. (2005). Don't worry, be happy? Neuroticism, trait-consistent affect regulation, and performance. *Journal of personality and social psychology*, *89*(3), 449-461.

Tamir, M., & Robinson, M. D. (2004). Knowing good from bad: the paradox of neuroticism, negative affect, and evaluative processing. *Journal of Personality and Social Psychology*, *87*(6), 913-925.

Tamir, M., Robinson, M. D., & Clore, G. L. (2002). The epistemic benefits of trait-consistent mood states: An analysis of extraversion and mood. *Journal of personality and social psychology*, *83*(3), 663-677.

Tamir, M., Schwartz, S. H., Oishi, S., & Kim, M. Y. (2017). The secret to happiness: Feeling good or feeling right?. *Journal of Experimental Psychology: General*, *146*(10), 1448-1459.

Tamir, M., Vishkin, A., & Gutentag, T. (2020). Emotion regulation is motivated. *Emotion, 20*(1), 115-119.

Thake, J., & Zelenski, J. M. (2013). Neuroticism, BIS, and reactivity to discrete negative mood inductions. *Personality and Individual Differences*, *54*(2), 208-213.

Tiedens, L. Z., & Linton, S. (2001). Judgment under emotional certainty and uncertainty: The effects of specific emotions on information processing. *Journal of Personality and Social Psychology, 81*(6), 973-988.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124-1131.

Valentine, P. V., & Smith, T. E. (2002). Finding something to do: The disaster continuity care model. *Brief Treatment & Crisis Intervention*, *2*(2) 183-196.

Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition and Emotion*, *21*(2), 391-403.

Von Hippel, W., & Gonsalkorale, K. (2005). “That is bloody revolting!” Inhibitory control of thoughts better left unsaid. *Psychological Science*, *16*(7), 497-500.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology*, *54*(6), 1063-1070.

Wei, M., Vogel, D. L., Ku, T. Y., & Zakalik, R. A. (2005). Adult attachment, affect regulation, negative mood, and interpersonal problems: The mediating roles of emotional reactivity and emotional cutoff. *Journal of Counseling Psychology*, *52*(1), 14-24.

Wheeler, R. E., Davidson, R. J., & Tomarken, A. J. (1993). Frontal brain asymmetry and emotional reactivity: A biological substrate of affective style. *Psychophysiology*, *30*(1), 82-89.

Wiebe, S. A., Espy, K. A., & Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology*, *44*(2), 575-587.

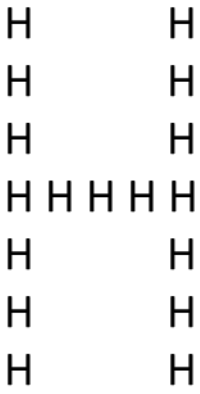
Xu, M., Rowe, K., & Purdon, C. (2020). Examining the Impact of a Single Session of Mountain Meditation on Attentional Scope. *Journal of Cognitive Enhancement*, *4*(2), 155-166.

Yik, M., Russell, J. A., & Steiger, J. H. (2011). A 12-point circumplex structure of core affect. *Emotion*, *11*(4), 705-731.

Zelazo, P. D., & Frye, D. (1998). Cognitive complexity and control: II. The development of executive function in childhood. *Current Directions in Psychological Science*, *7*(4), 121-126.

Appendix: Sample Navon stimuli from Study 2

Congruent:



Incongruent: