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The Impact of Negative Mood on Cognitive Control

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The current study aimed to determine the effect of both negative and positive mood on working memory (WM). Using a sample of undergraduates (N = 104), we investigated three specific topics: 1) if differences in trait affect and induced mood revealed specific impairments in WM; 2) the interplay between trait affect, induced mood, and dynamic adjustments in cognitive control; 3) the impact of baseline WM capacity on emotion manipulation and subsequent task performance. Participants completed one of three (Positive, Neutral, or Negative) 10-minute mood induction phases prior to a WM delayed-recognition task. Demand levels (high vs. low) of WM maintenance (memory load of 2 items vs. 1 item) and delay-spanning distractor interference (confusable vs. not confusable with memoranda) were manipulated using a factorial design during the task. The effect of positive mood on overall performance demonstrated an interaction between trait positive affect (PA) and induced mood. The interaction indicated that individuals with high (vs. low) trait PA performed worse when induced into a Happy mood and performed better than individuals with low PA when induced into a Sad mood. Also, trait PA was associated with decreased interference effects across all mood conditions. The effect of negative affect on WM performance was specific to the Neutral mood condition, and was associated with increased interference demand effects. Previous trial-based analyses indicated that both positive and negative

affect do not significantly moderate WM demand-triggered dynamic adjustments in cognitive control. Finally, WMC did not significantly predict either change in emotion during the mood induction procedure, or level of performance on the delayed-recognition task.

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CHAPTER 1: INTRODUCTION

Working memory (WM) is an essential cognitive process within the domain of cognitive control, sensitive to both changes in demand (Jha & Kiyonaga, 2010) and intraindividual variability (Sliwinski et al., 2006). WM refers to the temporary storage and active manipulation of information in short-term memory (Baddeley, 1992). It comprises several cognitive control functions, including memory maintenance, manipulation, and attentional inhibition of irrelevant distractions. Working memory is an essential cognitive process associated with many adaptive functions such as behavioral inhibition (Roughan & Hadwin, 2011), planning (Altgassen et al., 2007), and decision making (Hinson et al., 2002). In addition, WM has been demonstrated to be vulnerable to changes in one's mood state (Mitchell & Phillips, 2007). The purpose of the current study was to investigate the effect of positive and negative mood on WM performance, and how these effects may change as a function of increased maintenance and interference demands, trait-level mood, dynamic adjustments in cognitive control, and baseline WM capacity.

Research has demonstrated that both the subjective and biological presentations of positive (PA) and negative affect (NA) are not simply two opposite emotions along the same continuum, but instead represent two independent affect states (Watson & Tellegen, 1985; Ashby et al., 1999). Support for this hypothesis is found in evidence that the intra-individual correlation between subjective reports of positive and negative affect is only moderate (Carstensen, et al., 2000; Watson et al., 1988). Neuroimaging research has also demonstrated that happiness and sadness are mediated by independent neural pathways (George et al., 1995) and may be localized in different cerebral hemispheres (Davidson, 1992; Henriques & Davidson, 1991). A such, the current study posited that positive and negative moods may have an independent and dissociable impact on WM performance, and the independent demand features of cognitive control (i.e., maintenance & distraction interference).

1.1 Positive Affect and Working Memory

The effect of PA on cognitive control is mixed and variable to both the nature cognitive demand and strength of emotion (Isen, 1999). However, a great body of research has demonstrated that induced PA may cause impaired executive functioning and working memory capacity (Mitchell & Phillips, 2007). For example, Rowe, Hirsh and Anderson (2007) demonstrated that PA caused impaired inhibitory control of visual information during the Eriksen Flanker task (Eriksen & Eriksen, 1974). In addition, Martin and Kerns, (2011) experimentally induced participants into either a positive or neutral mood state using short video clips and demonstrated that positive mood caused significantly worse working memory capacity on a running span task (Cowan, Elliott, et al., 2005).

There have been multiple proposed mechanisms to explain the relationships between positive mood and working memory. One hypothesis is in line with the broaden-and-build theory (Fredrickson, 2001), and states that during positive moods there is an expansion of awareness that broadens one's thought-action repertoires leading to greater diversity in thoughts and actions that may arise in consciousness. Such broadened attention is associated with greater cognitive flexibility (Isen, 2007) and psychological resiliency (Tugade & Fredrickson, 2000); however, it may also lead to greater susceptibility to the influence of irrelevant and distracting information (Biss & Hasher, 2011). Consistent with this view is evidence that positive emotion expands the visual field of view (Schmitz, De Rosa, & Anderson, 2009) and limits one's inhibitory control to suppress irrelevant information from interfering with one's focus of attentional (Hasher, Zach, & May, 1999; Goeleve, De Raedt, & Koster, 2007). In sum, PA may serve to expand ones visual awareness during WM, and simultaneously increase one's vulnerability to the interference of distracting information.

In line with broaden-and-build theory (Fredrickson, 2001) is the affect-as-information model of the effect of mood on cognition (Schwarz & Clore, 1983; Schwarz, 1990). According to this model, affective states are used to inform an individual about the potential threats of their environment and cognitive resources necessary for survival. In positive mood states, individuals receive 'information' that their environment is then safe and benign, and therefore a more heuristic and nonrigorous thought-processes are engaged (Schwarz & Clore, 2007; Bless et al., 1996). However, heuristic processing may then be linked to poorer performance in WM, due to the required cognitive control processes of engaged attention and low distractibility (Dreisbach & Goschke, 2004).

In addition, Dreisbach (2006) demonstrated that induced positive mood may reduce maintenance ability during WM due to increased cognitive flexibility. Using a simple cuing paradigm (the AX Continuous Performance Task; Servan-Schreiber, Cohen, & Steingard, 1996), Dreisbach (2006) demonstrated that on trials where more rigid maintenance of a target image was beneficial to performance, individuals in the positive mood (vs. Neutral) condition performed worse. However, PA was associated with reduced error rates on trials where the release of focus on a target item, and instead rapid, flexible updating of a cognitive set was beneficial to performance. Dreisbach (2006) concluded that maintenance capacity and cognitive flexibility are antagonistic control demands, and that PA may direct one in favor of greater flexibility at the cost of maintenance.

A third hypothesis is that positive emotions occupy a limited source of attentional resources necessary for cognitive tasks which results in attentional costs. During positive states there may be an increased activation of associative cognitions and ruminations that occupy one's awareness (Mackie & Worth, 1989; Seibert & Ellis, 1991). Therefore, on tasks with a high demand, performance is decreased due to a reduced availability of attention resources (Mitchel & Phillips, 2007).

Contrary to the presented evidence, however, PA has also been associated with improved cognitive control. This effect has been elucidated in proponent response inhibition tasks (Kuhl & Kazen, 1999), complex decision making tasks (Carpenter et al., 2013), and antisaccade tasks (Van der Stigchel, et al., 2011), among others (Isen, 2008). In addition, Yang, Yang, and Isen (2013) demonstrated that induced positive mood caused increased in WMC, compared to neutral on an operation span task. In addition, Brose, Lovden and Schmiedek (2013) conducted a recent micro-longitudinal study demonstrating that daily variations in positive mood were positively associated with improved performance on WM tasks. Additional evidence suggests that PA also may have an advantageous effect on WM ability.

One proposed reason for the association between PA and improved WM ability is that positive mood states are often associated with additional cognitive and behavioral attributes that may assist with performance. Examples of this include greater feelings of energy (Lyubomirsky, King & Diener, 2005) which may lead to increased persistence

(Kuhl, 1987), as well as an increased sense of control (Cacioppo, Gardner, & Berntson, 1999) and more creative problem solving abilities (Isen, Daubman, & Norwicki, 1987). This is consistent with Brose et al., 2014. They reported that participants' self-reported positive mood on the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegan, 1988) was also associated with increased scores of self-reported motivation following each WM task, which may have also contributed to increased performance.

An additional model regarding the effect of PA on performance is derived from the neuropsychology approach, addressing the relationship between the neurotransmitter, dopamine (DA), and positive mood (Ashby, Isen, & Turken, 1999; Cools & D'Esposito, 2011). There is a body of empirical evidence to suggest that DA is associated with the subjective experience of PA. For example, drugs that mimic the effect of dopamine, such as morphine, cocaine, and amphetamines have been demonstrated to induce experiences of elation (Beatty, 1995). The same is true for the natural release of endorphins that stimulate the DA system (Harte, Eifert, & Smith, 1995). In addition, neuroleptic drugs that act as DA antagonists have been demonstrated to induce side effects of flattened PA (Ashby et al., 1999).

With regard to the relationship between DA, positive affect, and WM performance, neurobiological research has focused on DA projections from the ventral tegmental area (VTA) to the prefrontal cortex (PFC), as part of the mesocorticolimbic system. There is empirical evidence to suggest that working memory is partly facilitated by these projections to the PFC (Ashby et al., 1999). Animal studies have demonstrated that experimental reduction of DA in the PFC causes weaker performance on a delayed response WM task in monkeys (Brozoski et al., 1979). Among humans, depletion of dopamine in the PFC, inherent to patients with Parkinson's disease, also causes working memory deficits (Gotahm, Brown, & Marsden, 1988; Levin, Labre, & Weiner, 1989). Moreover, the experimental administration of DA agonists in human populations has been demonstrated to facilitate delayed-response WM performance (Luciana, Depue, Arbisi, & Leon, 1992; Müller, von Cramon, & Pollmann, 1998). In addition, DA stimulation in the PFC has been associated with increased PA (Phillips, 1984; Phillips et al., 1992). Thus, there is ample empirical support to suggest that the connection between PA and WM performance may be mediated by the release of DA in the PFC.

However, Cools and D'Esposito (2011) suggest that this effect of DA on WM is subject to inter-individual variability, and displays more of an inverted-U-shaped trend on performance. Research has demonstrated that the impact of DA on WM performance may vary as a function of baseline working memory capacity (Kimberg et al., 1997), baseline DA levels in the PFC (Zahrt et al., 1997; Cai & Arnsten, 1997), or also one's genetic disposition for DA sensitivity (Slifstein et al., 2008). Essentially, individuals with lower baseline DA in the PFC will benefit from DA agonists; however, those with high baseline levels, or increased DA sensitivity, will incur a cost to greater DA stimulation. As such, Cools and D'Esposito describe how the effect of DA on WM performance resembles an inverted-U-shaped curve. Both during DA depletion (low baseline and no stimulation) and DA 'over-dosing' (high baseline and stimulation) individuals show deficits in WM performance. In sum, according to this dopamine-based model, moderate levels of PA may be the key to ultimate WM performance.

In sum, there is mixed evidence regarding the effects of PA on WM. Positive affect has been demonstrated to cause both salutary (Yang, et al., 2013) and deleterious

(Cowan, Elliott, et al., 2005) effects on WM performance. Some of the basic cognitive features associated with PA are a broadened awareness (Fredrickson, 2001), heuristic (Schwarz & Clore, 2007), non-rigorous (Bless et al., 1996), and increased in flexibility at the cost of maintenance (Dreisbach, 2006), together representative of greater top-down versus bottom-up cognitive orientation (Clore & Huntsinger, 2007). However, Cools and D'Esposito (2011) have also demonstrated that the effects of PA on WM are likely sensitive to individual variability. In sum, there is evidence to suggest that the underlying cognition features associated with PA may serve to either benefit or harm WM performance, dependent on the nature of demand and individual sensitivity.

1.2 Negative Affect and Working Memory

The most consistent findings suggest that negative mood states are associated with impaired cognitive functioning (Grant et al., 2001; Hammar & Ardal, 2009) including lower working memory capacity (Brose et al., 2012). Research in clinical settings has demonstrated that depressed populations have poorer working memory capacity compared to healthy controls (Rose & Ebmeier, 2006; Harvey et al., 2004). These effects are also evident among healthy individuals after negative-mood inductions (Ellis et al., 1997), such that induced negative mood states are associated with decreased performance. However, the means by which negative mood impairs WM is still debated.

One leading argument is that negative mood depletes individuals of their limited attentional resources (Ellis & Ashbrook, 1988). Research has demonstrated that individuals in negative mood states have an attentional bias towards negative stimuli (Beck, 1967). Also, increased NA is associated with greater thought recycling, (i.e. rumination; Nolen-Hoeksema et al., 2008). Curci et al., 2013 also demonstrated that the deleterious impact of induced sad moods on WM performance is partly mediated by increased rumination. Klein and Boals, (2001) provided added evidence that memories of negative life events may share similar cognitive resources as those necessary for WM. In addition, during states of negative mood, attentional resources may also be directed towards the effort of emotion regulation (Riediger et al., 2011). In sum, negative attention bias, rumination, and emotion regulation all withdraw attention resources that could otherwise be utilized for cognitive tasks, such as information maintenance and filtering of irrelevant distractions during WM. As such, the limited attentional resource available among those in negative mood states is likely to impair WM abilities.

The Processing Efficiency Theory, postulated by Eysenck and Calvo (1992) suggests that cognitive demand may moderate the effects of negative emotion on WM performance. According to this view, processing efficiency is a product of the relationship between performance effectiveness and the effort or resources expressed to reach that performance (Eysenck & Calvo, 1992). Simply, equal effectiveness with fewer resources creates greater efficiency. In some circumstances, performances between individuals with happy and sad mood may be equally effective. However, given the limited attentional resources among those in negative moods, their performance will require greater compensatory effort, and therefore be less efficient. This is likely to be true on tasks of low demand that require few resources. However, when demand is high, the limited resources still available to those in negative moods are not sufficient enough to compensate, and the effects of mood are then elucidated in weaker performances. Eysenck and Calvo’s theory was originally adapted to anxiety. However, it is appropriate to extrapolate to depressed mood in this context, given that both are associated with decreased attentional capacity (Rokke et al., 2002; Eysenck et al., 2007) and impaired WM (Rose & Ebmeier, 2006).

A recent study by Li et al., (2012) demonstrated this modulatory effect of WM load on the relationship between emotion and WM performance. Li et al., (2012) used both behavioral and event-related potential (ERP) measures to test the effect of mood on WM performance. The task was a 0 (low load) or 2 (high load) n-back, WM paradigm (see Kirchner, 1958 for review). Positive, Neutral, and Negative moods were induced using mood-specific images selected from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2001), presented between target images within the n-back task presentation. Results demonstrated mood effects only on the high load task, such that participants in Negative moods performed worse than in Neutral and Positive mood. However, no mood effects were evident on the low load, 0-back WM task. Their results demonstrated that cognitive demand modulates the effect of emotion on WM performance, such that the deleterious effects of negative mood are greater with increased WM load.

In sum, the bulk of evidence suggests that negative mood results in deleterious consequences on WM. These effects are likely due to a reduction in necessary attention that is instead directed towards alternative negative stimuli (Beck, 1967), rumination (Nolen-Hoeksema et al., 2008), and the active down regulation of these negative emotions (Riediger et al., 2011). In addition, the impact of NA on cognitive control is likely to be elucidated with increased cognitive demand (Eysenk and Calvo, 1992; Li et al., 2012).

1.3 Mood and Dynamic-Adjustments in Cognitive Control

A staple feature of cognitive control is its ability to adapt to changes in situational environmental demands. On trial-based cognitive tasks such as the Flanker (Eriksen & Eriksen, 1974) or Stroop (Stroop, 1935), people perform worse on incongruent (conflict) trials than on congruent. However, further investigations in the trial-by-trial change in performance among these paradigms demonstrated that people's performances are greater on trials preceded by conflict (Egner, 2007; Gratton et al., 1992). It is hypothesized that individuals up-regulate in cognitive control to overcome this present conflict. This up-regulation in control then carries over to subsequent trials, evident in the form of performance benefits (Botvinick et al., 2001). These dynamic changes in cognitive control have been commonly defined as Conflict Adaptation.

A study by Jha and Kiyonaga (2010) further demonstrated these dynamic changes in cognitive control within the context of WM. Instead of a conflict task, they presented participants with a delayed-recognition WM paradigm. Cognitive demand was moderated by high (2 images) or low (1 image) WM load, as well as high (congruent) or low (incongruent) distractor interference. Results indicated that similar to conflict paradigms (e.g., Flanker & Stroop), participants' performance was best following trials of greater cognitive demand. This study demonstrates that similar to conflict, high cognitive demand in WM inspires up-regulation in cognitive control.

Recent studies have also provided evidence suggesting that mood may affect conflict-triggered dynamic changes in cognitive control. Work by Henk van Steenbergen and colleagues has demonstrated that negative mood is associated with greater conflict-inspired adjustments in cognitive control (van Steenbergen, et al., 2010, 2012). Kuhbandner and Zehetleitner (2011) demonstrated similar results, indicating that induced negative mood caused greater conflict adaptation using a visual pop-out task. The proposal based on these results was that negative mood states may increase sensitivity to conflict, via negativity biases (Beck, 1976), as well as greater neural reactivity to adverse and demanding events (Olvet & Hajcak, 2008; Pizzagalli et al., 2006). Additionally, van Steenbergen et al., (2010 & 2012) state that based on the Mood-Behavior Model (Gendolla, 2000), NA inspires increased mobilization of behavior and cognitive resources to meet these present demands.

van Steenbergen, et al., 2010, also demonstrated that, compared to negative mood, states of positive valence (i.e., Happy & Calm) were associated with attenuated measures of conflict-triggered adjustments in control, when compared to neagtive. However, minimal additional research has been able to shed light on the effect of positive (vs. Neutral) mood on conflict adaptation. There is some evidence to suggest that receiving a reward may remove the conflict adaptation phenomenon (van Steenbergen et al., 2009). van Steenbergen et al., (2009) demonstrated that conflict-driven adjustments in performance were reduced on trials where conflict was followed by a monetary reward (vs. monetary loss). In this context, it is hypothesized that receiving a reward counteracts the experience of conflict and therefore removes one's trigger to up-regulate in control. Taken together, research suggests that individuals in negative mood states are more sensitive to conflict and therefore generate greater effort to overcome such conflict when it arises, while positive mood may counteract one's subjective experience of conflict and therefore cause reduced dynamic adjustments in control. However, the relationship between mood and dynamic adjustments within the context of WM has yet to be investigated.

1.4 Working Memory Capacity and Emotion Regulation

Trait working memory capacity has significant implications on emotion regulation abilities. Research by Schmeichel et al. (2008) indicated that WMC is associated with individuals' ability to decrease one's emotional expression and experience in the presence of both positive and negative stimuli. Participants in the study were instructed to suppress their emotional response to film clips selected to elicit both disgust and humorous responses. Results demonstrated that those with high WMC were better able to suppress their emotional expressions to the evocative film clips. This work provides evidence to suggest that WM is necessary for the regulation of emotion expression. In addition, fMRI research has demonstrated that individuals with high familial risk for depression share similar neural responses during WM performance as depressed patients (Mannie et al., 2010). This suggests that impairment in WM processes may be a risk factor for later development of mood disorders. Also, research has demonstrated that improved WMC, via mindfulness practices, is associated with less negative mood during high stress situations (i.e., war pre-deployment) among military personnel (Jha et al., 2010). This suggests that greater WMC may protect individuals from emotionally evocative circumstances.

In sum, there is empirical evidence to suggest that WMC is a key cognitive control feature necessary for emotion regulation.

1.5 The Current Study

The overarching aim of the current project was to examine the interrelationships between mood and cognitive control. Mood was examined via induction as well as assessment of trait-level effects, and cognitive control was examined via parametric manipulation of WM demand as well as dynamic trial-by-trial adjustments.

The first aim of the current study was to investigate the modulatory effects of cognitive demand on mood-based WM performance impairment and/or improvement. A delayed-recognition, WM paradigm enables testing for the dissociable effects of demand via increased mnemonic load and increased distractor interference on the relationship between mood and performance. It was hypothesized that high demand in both load and interference will independently modulate the proposed effects. In addition, it is expected that this effect will be greatest on trials of both high load and high interference, given that among all four trial conditions, these are most demanding (Jha & Kiyonaga, 2010) and require the most attentional resources.

The second aim of the present study was to investigate the effects of mood on dynamic changes in cognitive control in the context of WM. Happy, Neutral and Sad mood conditions will be induced using a mood-specific, music and autobiographical memories. Dynamic adjustments in cognitive control will be measured using the stated delayed-recognition WM paradigm (Jha & Kiyonaga, 2010). Based on evidence by Jha and Kiyonaga (2010), we expected dynamic adjustment to be trigged by previous trials of high load and high interference demand. Investigations in the effect of positive and negative mood on WM demand-triggered dynamic adjustments in cognitive control are exploratory in nature, given that this is the first known study to address this relationship.

The predominant methods for examining the effects of mood on cognitive functioning have utilized either measure of the correlations of inter- and intra-individual differences in affective states or the direct effects of experimentally induced mood groups. Both methods have their strengths and weaknesses. Individual-based differences in dispositional mood provide a more natural representation of emotional states. However, correlational methods do not allow for strong conclusions about the causal direction of effects and are susceptible the influence of confounding variables. Experimental designs with random assignment provide greater protection from the problems of causal directionality and confound variables; however, induced affect states are more limited in their ecological validity. Cools & D'Esposito (2011) discussed how trait variability may influence the effects of DA stimulation on WM performance. However, there is minimal neurobehavioral research that has evaluated the interaction between dispositional self-reported affect states and induced mood on cognitive functioning. As such, Aim's 1 and 2 of present study were designed to assess WM performance both as a function of participants' dispositional trait affect, randomly assigned mood induction condition, and their interaction.

The third aim was to investigate the effect of WMC on WM task performance as a function of change in affect as a function of the mood induction procedure. It was predicted that increased WMC would predict greater WM task performance. Also, based on previous literature, it was hypothesized that WMC would predict greater change in mood, due to increased ability to regulate one's emotions (Schmeichel et al., 2008). In addition, it was hypothesized that greater change in mood would have a negative effect on WM task performance due to depletion in limited attention resources (Ellis & Ashbrook, 1988).

1.6 Summary of Hypotheses

The hypotheses for the current study were as follows:

Aim 1: *Effect of mood on WM performance.*

i. Consistent with the "Inverted-U-Shape" model (Cools & D'Esposito, 2011), it is proposed that there will be a significant interaction between trait positive affect and induced mood, such that high trait positive affect will be associated in impaired performance among those induced into happy mood and low trait positive affect will be associated with impaired performance among those induced into the sad mood condition. In addition, it is hypothesized that both maintenance and interference demand will be sensitive to change in positive affect.
ii. It is proposed that due to limited attentional resources, negative affect (trait & induced) will be associated with poorer working memory performance, and interference demand will most sensitive to the effect of negative affect.
iii. There will be a significant interaction between trait negative affect and induced mood condition, such that the negative effect of trait negative affect will be removed in the Happy mood condition and exacerbated in the Sad mood condition.

Aim 2: *Effects of mood on WM demand-triggered dynamic adjustments in cognitive control*.

i. Consistent with Jha & Kiyonaga (2010), it is predicted that increased maintenance and interference demand will trigger up-regulation in cognitive control.
ii. Based on van Steenbergen et al., (2009, 2010 & 2012), it is predicted that increased negative affect (trait & induced) will be associated with increased

dynamic adjustments, while positive affect (trait & induced) will be associated with attenuated dynamic adjustment effects.

Aim 3: *Effect of working memory capacity on delayed-recognition working memory performance, mediated by emotion change via the mood induction procedure*.

i. Working memory capacity will predict increased WM task performance; however, WMC will have a significant and negative indirect effect on WM task performance, mediated by the magnitude of affect change via the mood induction procedure.

CHAPTER 2: METHODS

2.1 Participants

One hundred and four participants (*M* age = 19.1, 57% female) were recruited from the University of Miami, Coral Gables, FL student population. Participants received either course credit or monetary payment as compensation for participation. Ten participants were not included due to attrition for Day 2 testing and 2 participants were excluded due to a performance three standard deviations below the mean on the delayed recognition cognitive task. Final analyses included 92 participants and they were each randomly assigned to one of three mood conditions, Happy (*n* = 31, *M* age = 18.9, 68% female), Neutral (*n* = 29, *M* age = 19.22, 55% female), or Sad (*n* = 30, *M* age = 19.23, 63% female) (See Table 2.1 for full demographics).

2.2 Procedure

2.2.1 Day 1 Experiment session and self-report measures

At a preliminary laboratory session, participants were provided informed consent and asked to complete a series of questionnaires, the Operation Span Task (OSPAN; Turner & Engle, 1989), and a music rating task. Each participant completed Day 1 testing session in either a group (*n* = 37) or individual (*n* = 67) setting. There were no significant differences in performance on any self-report measure between those who had completed Day 1 in a group or individually (see Table 2.2). Questionnaires included measures of demographic information, Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983), Center for Epidemiologic Studies Depression Scale (CESD; Radloff, 1977), the Emotion Regulation

Questionnaire (ERQ; Gross & John, 2003), and the Marlow Crowne Social Desirability Scale (MCSDS; Crowne & Marlowe, 1960).

The operation span task (Ospan; Turner & Engle, 1989) is a test of working memory capacity. The Ospan task required participants to remember a series of presented letters, ranging three to seven letters in length, while completing basic math problem presented between each letter presentation. Performance on the Ospan task is reported in five index scores. However, the current study used only the OSPAN Score index, which is calculated by adding up the number of items in perfectly recalled trials.

2.2.2 Music rating task

Participants were instructed to listen and rate there affect and arousal response to nine shortened musical selections. All musical selections were selected from validated experimental research studies using music-based mood induction procedures to induce Happy, Neutral, and Sad moods (See Table 2.3 for song listing). The nine songs (three per mood group) were pseudorandomly ordered into 6 unique series. This ordering was designed to remove any repetition in music valence and control for potential contrast effects in affect ratings. Each participant was randomly assigned one of the six unique music order series. Participants' self-reported ratings were made on the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) for both affect and arousal (See figure 2.1 A & B). SAM affect ratings were later used to allocate participant-specific musical selection per their randomly assigned mood condition. Participants in the Happy condition were assigned the song they rated the highest, Sad condition the song they rated the lowest, and Neutral condition the song they rated closest to a '5' on the SAM Affect scale. If multiple songs shared a condition-desired SAM rating, the experimental song was chosen at random from those identified. The rating procedure is to account for the subjective nature of music's emotional influence (Gabrielsson, 2002).

2.2.3 Day 2 experiment session

On the second testing day, participants were individually seated in a quiet, noise cancelling room, 57 centimeters away from the computer screen. Day 2 experiment sessions were completed between 1 to 7 days following Day 1. Participants first were provided the PANAS questionnaire. Following the questionnaire, a research assistant informed participants that the present study is one testing the relationship between emotion and cognition and that it will include both a mood induction procedure and cognitive task.

Using the computer, participants then began the working memory task instructions. Task instructions also included six practice trials, with performance feedback following each trial. If participants performed below 80% on the six practice trials, they were instructed to complete 6 additional practice trials with feedback. The WM delayed-recognition trials include three sequential events 1) memory item 2) delay period and 3) test item. All presented stimuli were grayscale images centrally located on the computer screen. Memorize items (S1) is presented for 3000 milliseconds (msec.) and will vary between high (2 images) or low (1 image) load and image domain (faces or shoes). S1 was followed by a delay period lasting 3500 msec., total. During this time, two additional distractor images (D1 & D2) were presented (1000 msec. each). D1 and D2 shared the same image domain and each was neither a copy of the other nor any other image presented in the experiment. Distractor images on trials of high distractor interference shared the same domain as S1 and test image (S2). Low interference trials presented distractor images (D1 & D2) of a different domain than S1 and S2. A fixation cross was presented for 500 msec. before, between, and after the presentation of D1 and D2.

Following the delay period, a single image in S2 was presented for 2500 msec. On match trials (50%), S2 was one of the previously presented images in S1. Nonmatch trials presented an image in S2 different from both S1 and all other images presented within the experiment. S1 and S2 shared the same image domain on all trials. S2 was followed by an additional fixation cross for 500 msec. before the immediate presentation of the next trial. Participants were instructed to determine if the S2 image matched S1 image as quickly and accurately as possible using designated keys on the keyboard. The experiment included an equal number of trials for each level of load, interference, match, and domain. See Figure 2.2 for a visual representation of the delayed-recognition working memory trials.

The participant then began the automated mood induction procedure. The mood induction procedure began with a pre-recorded visual text and vocal mood induction instructions presented via an E-prime (Schneider et al., 2002) computer-based program. Instructions included requesting participants to re-live a mood-specific memory in order to become as (Happy, Neutral or Sad) as possible while listening to music designed to elicit their desired emotional state. Instructions were based off those used in Jeffries et al., 2008 (see Figure 2.3 for transcript). Following instructions, participants were then provided 10 minutes to listen to their predetermined musical selection and re-live the autobiographical memory of their designated mood state. Participants also recorded their affective state on the SAM affect scale both before and after the 10 minute induction phase. The selected music was left playing softly, but audibly, through the remaining experiment.

After the 10-minute mood induction, participants began the delayed-recognition trial blocks. Each block consists of 33 trials. The two independent variables of primary interest were mnemonic Load and distractor Interference. The 2 X 2 factorial design provided an equal number of 4 possible trial types: a) High Load/High Interference b) High Load/Low Interference c) Low Load/High Interference and d) Low Load/Low Interference. Trials were pseudorandomly ordered to control for both current trial (N) and current-by-previous trial (N-1) frequencies. The first block was considered additional practice to allow participants time to adjust to the paradigm without feedback. Data collected from the subsequent three blocks was used for analyses. Data collected from block 3 was eventually dropped from analyses (see section 3.2 for more details).

In addition, a two-minute "booster" version of the mood-induction procedure was completed between blocks to protect from potential loss of induced mood states. The selected song was play on regular volume and participants were asked to return to their mood-specific memory during these mood "boosts." Additionally, participants' affect state was self-reported using the Self-Assessment Manikin for Affect following each mood "booster" and at the very end of the task.

CHAPTER 3: ANALYSES

3.1 Aim-based statistical analyses

Behavioral performance on the delayed-recognition working memory task was measured by percent accuracy and reaction time (milliseconds). Trials with reaction times less than 200 milliseconds (msec.) were excluded. In addition, reaction time data was only collected on trials with correct accuracy. Analyses of current trial performance, based on previous trial WM demand, was selected for trials with only previous trial correct accuracy. This was to protect from potential error-based adjustments in performance (Forster & Cho, 2014). Behavioral data from two participants were removed from analyses, due to a performance three standard deviations below the mean accuracy across participants.

Statistical tests for the main effect of WM demand and the WM demand by mood condition interactions on performance were completed with repeated measures analyses of variance (ANOVA). Significant interactions were further assessed with one-way ANOVA's to test for performance difference between mood groups on select WM demand conditions. Pearson's r correlation analyses were conducted to test the association between trait positive and negative affect and WM performance. In addition, repeated measure ANOVA's were conducted to provide a preliminary investigation regarding the interactions between trait affect, mood condition, and WM demand. Trait affect was first included as a between-groups variable, split by the 1st and 4th quartiles of both positive and negative index scores, independently. Follow-up one-way ANOVA's and t-tests were completed to investigate significant trait affect by induced mood interactions. Results from these follow-up analyses were used as descriptive evidence to design regression models to better account for the presented interactions; therefore, they were uncorrected for multiple comparisons.

3.2 Removal of trial block three from analyses

The design of the delayed-recognition working memory task was based on the paradigm used in Jha and Kiyonaga (2010); however, the current study included an additional experimental block with the purpose of provide more power to detect mood-based differences in performance. The introduction of an additional trial block presented two preliminary concerns. One, the demand of the WM task may act as a distraction emotion regulation technique and participants' emotion may naturally deviate from their induced mood state throughout the task. Two, the introduction of an additional test block has not been tested, and participants' performance on the third block may decline due to fatigue. As such, two preliminary analyses were conducted to test for these hypotheses.

A repeated measure ANOVA was conducted to test for the stability of affect state across trial blocks. After each of the three experimental blocks, participants rated their current affect state on the SAM affect scale. Each participants' post-block SAM ratings were subtracted from their post-mood induction SAM ratings to provide a measure of affect-deviation from their induced mood state. Results indicated that there was a significant change in affect deviation across the three experimental blocks F (2, 90) = 9.691, p <.001 (See Figure 3.1 A). Additional paired sample t-tests indicated that participants' SAM deviation in block 1 (M = .6413, SD = .673) were not significantly different than block two (M = 66.30, SD = 82.91), t (91) = .271, p = .787. However, SAM deviation in block three (M = 1.00, SD = .983) were significantly greater than both block one, t (91) = 3.786, p < .001 and block two, t (91) = 4.10, p < .001. This suggests that participants' affective deviation from the induced emotional state was significantly greater in the third block than the first and second.

An additional repeated measure ANOVA was conducted to test for changes in accuracy performance across the three experimental blocks. Results demonstrated a significant difference in accuracy across blocks, F (2, 90) = 3.981, p = .022 (See Figure 3.1 B). In addition, paired t-tests between blocks indicated that accuracy on block one (M = 91.89, SD = 5.46) was not significantly different than block two (M = 93.01, SD = 5.95), t (91) = 1.747, p = .084, or block three (M = 91.14, SD = 7.89), t (91) = .968, p = .335. However, participants' accuracy on block three was significantly less than on block two, t (91) = 2.675, p = .009. These results are consistent with the preliminary concern that participants' performance may have declined on the last block due to cognitive fatigue.

These results suggest that block three may be an aberrant representation of participants' emotion-induced state and performance capabilities; therefore, behavioral results from this block were removed from further analyses and interpretations.

CHAPTER 4: RESULTS

4.1 Manipulation check

4.1.1 WM Demand

A 2 X 2 factorial, repeated measures analysis of variance (ANOVA) with independent variables, load demand (High & Low) and interference demand (High & Low) was conducted to assess the impact of working memory (WM) demand on performance, measured by percent accuracy and reaction time. Results indicated a significant main effect of load demand, such that percent accuracy was poorer on trials of high load (M = 90.45%, SD = 7.13) than low load (M = 95.44%, SD = 4.92), F (1, 91) = 56.653, $p < .001$, and a main effect of interference demand, such that accuracy was poorer on trials of high interference (M = 91.46%, SD = 6.67) than low interference (M = 95.44, SD = 4.92), F (1, 91) = 7.943, $p = .006$, and no significant interaction between load and interference demand, F (1, 91) = 2.268, $p = .136$ (See Figure 4.1 A). Results of reaction time performance were consistent with percent accuracy, indicating that performance was slower on trials of high load (M = 943.12, SD = 160.21) than low load (M = 799.33, SD = 151.73), F (1, 91) = 302.36, $p < .001$, and slower on trials of high interference (M = 896.21, SD = 158.97) than low interference (M = 843.93, SD = 149.56), F (1, 91) = 49.11, $p < .001$, and no significant interaction between load and interference demand, F (1, 91) = .024, $p = .877$ (See Figure 4.1 B). Results indicated that greater demand in both memory item load and distractor interference caused decreased WM performance.

4.1.2 Mood induction

A repeated measure ANOVA with a two-level, within-subject independent variable, SAM affect ratings (pre-induction SAM rating & post-induction SAM rating), and a three-level between-group independent variable, Mood Condition (Happy, Neutral & Sad), was conducted to test the effect of the mood-induction procedure on change in affect. Results indicated a significant change in SAM affect ratings from pre-to-post mood induction F (1, 89) = 54.402, $p < .001$ and that there was a significant interaction between the change in SAM ratings and mood condition, F (2, 89) = 140.940, $p < .001$ (See Figure 4.2). Additional paired-sample t-tests for each mood condition indicated that participants' SAM rating in the Happy condition were greater following the mood induction (M = 7.84, SD = .898) than before the mood induction (M = 6.26, SD = 1.06), t (30) = 8.322, $p < .001$. In the Neutral condition, participants' SAM ratings were lower post-mood induction (M = 5.0323, SD = .482) than pre-mood induction (M = 5.87, SD = 1.41), t (30) = 3.61, p = .001. In addition, participants in the Sad condition rated their SAM affect scale lower post-mood induction (M = 2.70, SD = 1.055) than pre-mood induction (M = 6.13, SD = 1.01), t (29) = 16.57, $p < .001$. Also, a one-way ANOVA indicated that there were no significant difference between mood conditions on pre-mood induction SAM affect ratings, F (2, 89) = .876, p = .420. These results demonstrated that participants' emotional states significantly changed due to the mood induction procedure and that this change was consistent with their randomly assigned mood condition.

4.1.3 Measure differences between mood conditions

A one-way ANOVA comparing the three mood conditions indicated no significant differences on all measures from both day 1 and day 2 experiment sessions (See Table 4.1).

4.1.4 PANAS index score distributions

Results also indicated that participants' responses on the positive and negative index scores of the PANAS self-report measure on day 2 of the study were representative of a normative sample of the general population (Watson, Clark & Tellegen, 1988). PANAS positive index scores in the present study (*M* = 30.337, *SD* = 7.25861) did not significantly differ from the normative sample collected in Watson et al., (1988) (*M* = 29.7, *SD* = 7.9), *t* (750) = .7315, *p* = .465. This was also true for PANAS negative index scores, as values from the present study (*M* = 13.93, *SD* = 3.189) did not differ significantly from those collected in Watson et al., (1988) (*M* = 14.8, *SD* = 5.4), *t* (750) = 1.50, *p* = .134. In addition, the Skewness and Kurtosis index values for both PANAS positive (-.351, -.217, respectively) and PANAS negative (.906, .682, respectively) index scores, indicated that both datasets represent a relatively normal sample distribution. Participants' responses were also consistent with the view that positive and negative affect are independent emotional states (Watson & Tellegen, 1985) as the negative correlation between these measures was small and non-significant (Pearson's $r = -.033$, $p = .76$).

There was also a significant correlation between Day 1 PANAS trait index scores and Day 2 PANAS state index scores for both positive (Pearson's $r = .46$, $p < .001$) and negative (Pearson's $r = .36$, $p = .001$) affect. These results suggest that the Day 2 PANAS state measure were representative of a Day 2 state-based deviation of their otherwise trait-based mood disposition. Due to its contrast with participant's induced emotion state and the purpose of the current study, pre-task PANAS state scores were identified as a measure of participants' interindividual variance in trait affect.

4.2 AIM 1: Mood by WM Demand Interaction

4.2.1 Effect of mood condition on WM performance

The repeated measure ANOVA conducted to test the effect of WM demand on performance was re-ran, including mood condition (Happy, Neutral & Sad) as a between-group independent variable. Results from the analysis with percent accuracy as the dependent variable indicated no significant interactions between mood condition and load demand F (2, 89) = 1.129, p = .328, mood condition and interference demand, F (2, 89) = .889, p = .415, or a three way interaction between mood condition, load demand, and interference demand, F (2, 89) = 1.156, p = .319. In addition, there was no significant difference in total accuracy between mood conditions, F (2, 89) = .553, p = .577 (See Figure 4.3 A). Results from the analysis with reaction time performance also indicated no significant interaction between mood condition and load demand, F (2, 89) = 1.073, p = .346. However, there was a significant interaction between mood condition and Interference demand, F (2, 89) = 3.596, p = .032, but no significant three-way interaction between mood condition, load demand and interference demand, F (2, 89) = .544, p = .582. In addition, there was no significant difference between mood conditions on total reaction time, F (2, 89) = .982, p = .379 (See Figure 4.3 B).

4.2.1.1 Congruency by mood condition reaction time follow-up analyses

Follow-up analyses were conducted to investigate the interference demand by mood condition interaction. One-Way ANOVAs indicated that there was no significant reaction time differences between mood conditions on all high interference trials, F (2, 89) = 1.358, p = .262 or on all low interference trials, F (2, 89) = .805, p = .450 (See Figure 4.4 A). However, results indicated a significant difference between mood conditions on the magnitude of the interference demand effect (high interference – low interference), F (2, 89) = 3.734, p = .028. In addition, follow-up independent t-tests comparisons indicated that interference effect magnitude was lower in the Happy condition (M = 27.31, SD = 65.58) than Neutral (M = 56.58, SD = 63.18), with moderately significance t (60) = 1.79, p = .079. Also, the congruency effect was significantly smaller in the Happy condition than the Sad condition (M = 73.66, SD = 72.25), t (59) = 2.623, p = .011. However, there was no significant difference between Neutral and Sad condition, t (59) = .983, p = .330 (See Figure 4.4 B). Results suggest that induced Happy mood may cause a decrease in the magnitude of the effect of interference demand on reaction time performance.

4.2.2 Trait affect and WM task performance

A series of correlations analyses were run to test the relationship between particpants' trait affect and performance on the delayed-recognition WM task. Results indicated that PANAS negative index scores did not significant correlate with total accuracy (Pearson's r = .069, p = .512) or reaction time (Pearson's r = -.044, p = .678) performance. Negative affect also was not associated with the magnitude of the load demand effect (low load – high load) in accuracy (Pearson's r = -.144, p = .171) or reaction time (Pearson's r = -.064, p = .548) nor the magnitude of the interference demand effect (low interference – high interference) for accuracy (Pearson's r = -.029, p = .645) or reaction time (Pearson's r = -.014, p = .893). PANAS positive index scores demonstred similar results, indicating no significant correlation with total accuracy (Pearson's r = .086, p = .414) or total reaction time (Pearson's r = -.075, p = .475) performance. Positive affect was also not associated with the magnitude of the load demand effect in accuracy (Pearson's $r = -.029$, $p = .786$) or reaction time (Pearson's $r = .032$, $p = .759$). However, there was a significant negative correlation between PANAS positive scores and the magnitude of the interference effect for accuracy (Pearson's r = -.212, $p = .042$, uncorrected) (see Figure 4.5); however, this relationship was not significant on reaction time (Pearson's $r = -.040$, $p = .703$). In summation, results indicate that trait NA is not significantly associated with overall WM task performance or the effect of load and interference demand; however, there was a significnat small to medium negative correlation between PA and the magnitude of the interference demand effect represented in performance accuracy.

4.2.3 Trait affect by mood condition by WM demand interactions

4.2.3.1 Trait positive affect

The previously conducted repeated measures ANOVA, testing the interaction between mood condition and WM demand, was re-run including an additional between-group independent variable for PANAS positive index scores. PANAS positive groups were distinguished by the 1st (PQ1) and 4th (PQ4) quartiles of PANAS index scores, within each mood condition. Results indicated no significant interactions between PANAS positive quartiles and load demand F (1, 47) = .225, $p = .637$ or three-way interaction between PANAS positive quartiles, mood condition, and load demand F (2, 47) = 2.404, $p = .101$. There was a trend level ($p < .1$) significant interaction between PANAS positive quartiles and interference demand F (1, 47) = 3.028, $p = .088$; however, no significant interaction between PANAS positive quartiles, mood condition and interference demand F (2, 47) = .906, $p = .411$. In addition, there was no significant interaction between load demand, interference demand and PANAS positive quartiles F

(1, 47) = .514, *p* = .477, nor a four-way interaction between load demand, interference demand, mood condition and PANAS positive quartiles *F* (2, 47) = .344, *p* = .711. Also, there was no significant difference in total accuracy performance between high and low PANAS positive quartiles, *F* (1, 47) = .286, *p* = .595. However, there was a significant between-subjects interaction between mood condition and PANAS positive quartiles on overall accuracy, *F* (2, 47) = 4.044, *p* = .024. The presented the repeated measure ANOVA was also conducted with reaction time as the dependent measure of WM performance; however, results indicated no significant interactions with PANAS positive quartiles and mood conditions or WM demand (See Table 4.2).

4.2.3.1.1 Trait positive by mood condition interaction follow-up

Follow-up one-way ANOVAs were conducted to investigate the significant mood condition by PANAS positive quartile interaction. Results indicated no significant difference between mood conditions among the PQ1 group, *F* (2, 24) = 2.424, *p* = .110 and no significant difference between mood conditions among the PQ4 group, *F* (2, 23) = 1.810, *p* = .186 (See figure 4.6). In addition, three independent sample t-tests were conducted to test the difference in accuracy between high and low PANAS positive quartiles (PQ1 & PQ4) at each mood condition. Results for the Happy condition indicated that accuracy performance in the PQ1 group (*M* = 95.39, *SD* = 2.53) was significantly greater than PQ4 (*M* = 91.41, *SD* = 5.19), *t* (17) = 2.081, *p* = .05. For the Neutral condition, there was no significant difference in performance between PQ1 (*M* = 91.61, *SD* = 4.55) and PQ4 (*M* = 92.73, *SD* = 2.85), *t* (15) = .602, *p* = .556. For the Sad condition, the accuracy performance in PQ1 (*M* = 90.21, *SD* = 7.26) was less than that of

PQ4 (*M* = 94.97, *SD* = 2.92); however, the difference was not statistically significant, *t* (15) = 1.727, *p* = .105 (See figure 4.7).

Based on these results, a regression analysis was also conducted to test the mood condition by PANAS positive quartile interaction, with PANAS positive index scores as a continuous variable. Post-mood induction SAM affect ratings were used as a continuous, and potentially more sensitive, measure of participants' induced affect state. As such, the regression model included total percent accuracy as the criterion, predicted by PANAS positive index scores, post-induction SAM affect ratings, and the interaction calculated as the product of these measures. Both PANAS positive index and SAM affect rating do not have a meaningful value for zero; therefore, both were centered on their mean value to remove any potential multicollinearity. Results indicated a significant interaction between PANAS positive and SAM ratings, *b* = -0.096, *t* (88) = 3.004, *p* = .003. Post-induction SAM scores did predict significant change in accuracy, *b* = .306, *t* (88) = 1.404, *p* = .164, when controlling for PANAS positive and the interaction effect. Results also indicated that with the moderator (SAM affect ratings) centered at its mean, PANAS positive scores did not predict significant change in accuracy, *b* = .054, *t* (88) = .592, *p* = .555. In addition, results indicated that PANAS positive scores, post-induction SAM ratings, and their interaction predicted a significant portion of variance in accuracy performance, R^2 = .107, *F* (3, 88) = 3.528, *p* = .018. To better interpret the interaction between PANAS positive and SAM ratings, the regression model was re-ran two additional times with SAM rating values centered at a value one standard deviation above and below the mean. Results indicated that with SAM rating scores centered at one SD above the mean, the effect of PANAS positive on accuracy is negative and moderately significant, *b* = - 0.177, *t* (88) = 1.733, *p* = .087; however, one additional analysis with SAM centered at 1.5 SDs above its mean, demonstrated a significant negative effect *b* = -.286, *t* (88) = 2.170, *p* = .033. At SAM ratings scores centered at one SD below its mean, the coefficient for PANAS positive is both positive and significant, *b* = .257, *t* (88) = 2.703, *p* = .008 (See Table 4.3, model A). In summation, regression analyses indicated a significant interaction between PANAS positive scores and SAM affect ratings, such that PANAS positive predicted greater performance in WM accuracy at low post-mood induction SAM affect ratings and decreased performance at high post-induction SAM affect ratings (See figure 4.8.).

4.2.3.1.2 Regression follow-up analyses

Two additional regression analyses were conducted to further investigate the WM demand that may be driving change in performance as a function of PANAS positive index scores and induced mood state. The first regression model replaced the total percent accuracy criterion in the previous model with the magnitude of the interference demand effect (accuracy on low interference trials – accuracy on high interference trials). This regression model did not account for a significant portion of variance in interference effect magnitude, R^2 = .057, *F* (3, 88) = 1.765, *p* = .160; however, consistent with the preliminary correlation results, PA predicted a significant decrease in interference effect magnitude, b = -.187, t (88) = 1.994, p = .049 (See Table 4.3, model B). The second regression model replaced the dependent variable, total percent accuracy, with the magnitude of the load demand effect (accuracy on low load trials – accuracy on high load trials). Results indicated that this model accounted for a moderately significant portion of variance in load effect magnitude, R^2 = .078, *F* (3, 88) = 2.470, *p* = .067 (See figure 4.9).

In addition, results from this model indicated a significant interaction between PANAS positive scores and post-mood induction SAM affect ratings, *b* = .136, *t* (88) = 2.678, *p* = .009. With the SAM affect ratings centered at its mean, PANAS positive did not predict significant change in load effect, *b* = -.007, *t* (88) = .065, *p* = .948. However, with SAM affect ratings centered at one standard deviation above its mean, the effect of PANAS positive scores on the load effect was positive and significant, *b* = .300, *t* (88) = 1.849, *p* = .048. In addition, with SAM affect ratings centered at one standard deviation below its mean, PANAS positive scores significantly predicted a decrease in load effects, *b* = -.314, *t* (88) = 2.082, *p* = .040. In summation, results indicated that the evidenced change in accuracy performance as a function of trait PA and induced mood-state is likely due to change in one's sensitivity to WM load demand.

4.2.3.1.3 Supplemental inverted-U-shaped analysis

The present interaction between trait PA and induced mood on WM performance is consistent with the inverted-U-shaped relationship as described by Cools & D'Esposito (2011). One additional analysis was conducted to test the proposed inverted-U-shape, or quadratic, relationship between trait PA and induced mood state on performance. A one-way ANOVA testing for a significant quadratic trend was conducted with six independent participant groups, separated by PANAS positive quartiles (PQ1 & PQ4) for each of the three mood conditions. Groups were organized from what may be theorized as the most PA deprived (PQ1/Sad condition) to most PA 'over-dosed' (PQ4/Happy condition). Results indicated that differences between group performance did represent a statistically significant quadratic, 'inverted-U-shape' relationship, *F* (1, 47) = 6.351, *p* = .015 (See Figure 4.10).

4.2.3.2 Trait negative affect

The previous conducted repeated measures ANOVA testing the interaction between mood conditions, positive affect, and WM demand was re-run, replacing the positive affect between-group independent variable with PANAS negative-based groups. PANAS negative groups were distinguished by the 1st (NQ1) and 4th (NQ4) quartiles of PANAS index scores, within each mood condition. Results indicated no significant interactions between load demand and PANAS negative quartiles, F (1, 49) = .492, p = .486, no significant three-way interaction between load demand, mood condition, and PANAS negative quartiles, F (2, 49) = .792, p = .459, and no significant interaction between interference demand and PANAS negative quartiles F (1, 49) = .085, p = .772. However, there was a significant three-way interaction between interference demand, Mood condition and PANAS negative quartiles, F (2, 49) = 4.565, p = .015. Although, there was no significant interaction between load demand, interference demand and PANAS negative quartiles, F (1, 49) = 2.675, p = .108 or a significant four-way interaction between load demand, interference demand, mood condition, and PANAS negative quartiles F (2, 49) = .684, p = .509. Finally, there was also no significant interaction between mood condition and PANAS negative quartiles on total accuracy, F (2, 49) = .853, p = .432 or a significant difference in performance between the first and fourth quartiles of the PANAS negative scores, F (1, 49) = .319, p = .575. The repeated measures ANOVA was also conducted with reaction time as the dependent measure of WM performance. Results from reaction time data indicated a significant four-way interaction between PANAS negative quartiles, mood condition, load demand, and interference demand, F (2, 47) = 3.257, p = .047. However, no other significant interactions between PANAS negative quartiles were evident in reaction time performance and due its complexity and inconsistency with the collective analyses, no further tests were conducted to investigate the four-way interaction.

4.2.3.2.1 Trait negative by mood by interference interaction follow-up

Follow-up analyses were conducted to investigate the three-way interaction between PANAS negative quartiles, mood condition and interference demand. One-way ANOVA's were conducted to test the difference in performance between mood conditions on each of the four possible condition of PANAS negative quartiles and interference demand trials. Results indicated a significant difference between mood conditions only among the NQ4 groups on high interference trials, F (2, 23) = 4.545, p = .022. However, there was no difference in accuracy performance between mood conditions among the NQ1 groups on high interference trials, F (2, 26) = .205, p = .816, among the NQ4 groups on low interference, F (2, 23) = .418, p = .663, or the NQ1 groups on low interference trials, F (2, 26) = 1.213, p = .314 (See figure 4.11). Additional independent sample t-tests between mood conditions for performance on high interference trials among the NQ4 groups indicated that the Neutral condition (*M* = 87.59, *SD* = 7.70) demonstrated worse performance than Happy condition (*M* = 94.09, *SD* = 4.26), with moderate significance, t (14) = 2.089, p = .055. The Neutral condition was significantly worse than the Sad condition (*M* = 94.91, *SD* = 3.99), t (16) = 2.612, p = .019. However, the performance on high interference trials was not significantly different between Happy and Sad, t (16) = .420, p = .680 (See figure 4.11 A). Results suggest that the leading cause of the three-way interaction between PANAS negative quartiles, mood condition, and interference demand is such that individuals assigned to the Neutral mood condition with high trait negative affect performed significantly worse on high interference trials than those in both the Happy and Sad condition, also with high PANAS negative scores.

A regression analysis was conducted to further investigate the three-way interaction between PANAS negative quartiles, mood condition, and interference demand. Similar to the regression model presented for the interaction between PANAS positive and mood conditions, the categorical Mood group predictor was replaced by post-mood induction SAM affect ratings to provide a more sensitive and continuous measure of one's induced mood state. Participants' calculated interference effect magnitude (low interference accuracy – high interference accuracy) was set as the criterion to account for the effect of interference demand. In addition, PANAS negative and SAM affect rating scores were centered on their respective means prior to calculating the analysis to remove potential multicollinearity between measures. Results indicated that the model did not account for a significant proportion of variance in interference effect, $R^2 = .005$, $F(3, 88) = .154$, $p = .927$ and none of the predictor coefficients were significant (See table 4.3, model D). These results suggest that both trait PANAS negative index scores and post-mood induction SAM affect ratings do not predict change in interference effect magnitude. In addition, there was no significant interaction, indicating that the effect of PANAS negative scores on interference magnitude is not moderated by SAM rating-based induced mood state.

Additional analyses were conducted to investigate the inconsistency between the significant interaction between PANAS negative, mood condition, and interference demand, evident in the repeated measure ANOVA, and null findings evident in the regression analysis. One potential cause may be that post-mood induction SAM affect ratings were not an appropriate index of induced mood in the context of negative affect. A regression model was conducted to investigate the independent predictive validity of PANAS positive and negative index score on pre-mood induction SAM affect ratings. Results indicated that positive index scores significantly predicted SAM affect ratings, $b = .083$, $t\ (89) = 5.78$, $p < .001$ when controlling for negative; however, negative index scores did not, $b = -.054$, $t\ (89) = 1.636$, $p = .105$, when controlling for positive. In addition, this model indicated that positive and negative PANAS index scores predicted a significant portion of variance in SAM affect ratings, $R^2 = .292$, $F\ (2, 89) = 18.357$, $p < .001$ (See table 4.3, model E). As such, the researches inferred that the measure of post-mood induction SAM affect rating may be a more sensitive measure of post-mood induction PA state than one's post-mood induction NA state. This measure has proven advantageous in the previously demonstrated context of the PANAS positive and induced mood state interaction; however, it is likely a poor measure of induced mood state in the current analyses regarding the interaction between PANAS negative, induced mood condition, and interference demand.

Therefore, an additional regression analysis was conducted including the categorical, between-group mood condition predictors instead of the previously used post-induction SAM affect ratings, to further assess the evidenced three-way interaction. Mood conditions predictors were specified using dummy coding. The present regression model included PANAS negative index scores, dummy coded mood-condition predictors, and PANAS negative index by mood group interaction. Interference effect magnitude in accuracy was the dependent measure. Results indicated that in the Neutral condition, PANAS negative scores predicted significantly greater interference effect, *b* = .916, *t* (86) = 2.497, *p* = .015. However, for the Sad condition, the prediction of PANAS negative scores on interference effect was negative, with only trend level significance (p <.10), *b* = -.564, *t* (86) = 1.690, *p* = .095. In addition, within the Happy condition, the effect of PANAS negative on the interference effect was also negative, but non-significant, *b* = -.572, *t* (86) = 1.452, *p* = .150. Interaction effects indicated that the beta coefficient for the Neutral condition was significantly different than both Happy condition (*b* = -1.488, *t* (86) = 2.755, *p* = .007) and the Sad condition (*b* = -1.479, *t* (86) = 2.973, *p* = .004). However, the coefficients between Happy and Sad were not significantly different, *b* = -.009, *t* (86) = .017, *p* = .987. Finally, regression results also indicated that the mean interference effect magnitude in the Neutral condition was significantly greater than both the Happy condition (*b* = 18.783, *t* (86) = 2.500, *p* = .014) and the Sad condition, (*b* = 18.802, *t* (86) = .011). However, the mean interference effect magnitude was not significantly different between the Happy and Sad conditions, *b* = .019, *t* (86) = .003, *p* = .998. PANAS negative index scores, mood conditions, and their interactions predicted a significant portion of variance in interference effect magnitude, R^2 = .132, *F* (5, 86) = 2.619, *p* = .030 (See Figure 4.12. & Table 4.3, model F). Results from the regression analysis suggest that increased PANAS negative scores predict greater interference effect in the Neutral condition, while the effect is both reversed and non-significant in both the Happy and Sad mood conditions. Regression results are consistent with previous ANOVA's , indicating a significant difference in the interference demand effect magnitude between the Neutral condition and both Happy and Sad, as a function of PANAS negative scores.

4.3 AIM 2: Mood by Previous Trial Demand Interaction

4.3.1 Main effects of previous trial demand on performance

A 2 X 2 factorial, repeated measures ANOVA with independent variables of previous trial (N-1) load demand (High & Low) and N-1 interference demand (High & Low) was conducted to test the effect of previous trial WM demand on current trial accuracy and reaction time performance. Results indicated that accuracy performance was greater following N-1 high load (*M* = 93.60., *SD* = 5.16) than N-1 low load (*M* = 91.90, *SD* = 6.16), $F(1, 91) = 6.631$, $p = .012$ and that accuracy was poorer following N-1 high interference (*M* = 91.34, *SD* = 6.29) than N-1 low interference (*M* = 94.05, *SD* = 5.68), $F(1, 91) = 12.727$, $p = .001$. In addition, there was no significant interaction between N-1 load and N-1 interference demand, $F(1, 91) = 1.183$, $p = .280$ (See Figure 4.13 A). These results were consistent with the analysis of reaction time performance, indicating that participants were faster following N-1 high load trials (*M* = 857.71, *SD* = 152.16) than N-1 low load (*M* = 875.30, *SD* = 158.92), $F(1, 91) = 5.244$, $p = .024$, and slower on N-1 high interference trials (*M* = 885.42, *SD* = 156.73) than N-1 low interference (*M* = 850.403, *SD* = 152.43), $F(1, 91) = 31.395$, $p < .001$. In addition, there was an interaction between N-1 load and interference demand on reaction time performance of moderate statistical significance, $F(1, 91) = 3.591$, $p = .061$ (See Figure 4.13 B). Results demonstrated that performance is greater following N-1 high demand; however, performance is poorer following N-1 high interference.

4.3.2 Mood condition by previous trial demand interaction

The previous stated repeated measures ANOVA testing the effect of previous trial (N-1) WM demand on accuracy and reaction time performance was re-run, including the additional between-groups independent variable, mood condition (Happy, Neutral & Sad). Results on accuracy performance indicated no significant interactions between mood conditions and N-1 load demand, F (2, 89) = .031, p = .970, N-1 interference demand, F (2, 89) = .972, .382 or three-way interaction between mood condition, N-1 load and N-1 interference demand, F (2, 28) = .972, p = .382 (See Figure 4.14. A). Results on reaction time analyses presented consistent results, indicating no significant interaction between mood conditions and N-1 load demand, F (2, 89) = .064, p = .938, N-1 interference demand, F (2, 89) = 1.034, p = .360, or a three-way interaction between mood condition, N-1 load and N-1 interference demand, F (2, 89) = .679, p = .510 (See figure 4.14 B). These results suggest that the effect of previous trial WM demand does not change as a function of one's induced mood state.

4.3.3 Trait affect and N-1 WM demand effects

A series of correlations analyses were run to test the relationship between particpants' trait affect and magnitude of N-1 WM demand effects. Results indicated that PANAS negative index scores did not significant correlate with the magnitude of the N-1 load demand effect in accuracy (Pearson's r = .087, p = .409) or reaction time (Pearson's r = -.007, p = .945) nor the magnitude of the N-1 interference demand effect for accuracy (Pearson's r = .115, p = .273) or reaction time (Pearson's r = -.030, p = .779). PANAS positive index scores demonstred similar results, indicating no significant correlations with the magnitude of the N-1 load demand effect in accuracy (Pearson's r = .166, p = .114) or reaction time (Pearson's r = -.079, p = .454) nor the magnitude of the N-1 interference demand effect for accuracy (Pearson's r = -.009, p = .993) or reaction time

(Pearson's r = .004, p = .969). Results indicated that trait affect is not significantly associated with the magnitude of N-1 WM demand effects for load or interference.

4.3.4 Trait affect by mood condition by prevoius trial WM demand Interaction

4.3.4.1 Triat positive and negative affect

The above repeated measure ANOVA's with independent variables of N-1 WM demand and between-group variable of mood condition were tested again, including a between-group measure of PANAS negative and positive index scores, independently. As previously stated, PANAS negative and positive groups were separated by the first and fourth quartile for each affect index, within each mood condition. Participant's accuracy results indicated no significant interactions between PANAS positive quartiles or PANAS negative quartiles with N-1 WM demand, or three-way interactions with both N-1 WM demand and mood condition (See Table 4.4). For reaction time performance, a significant three-way interaction between PANAS negative quartiles, N-1 load demand and N-1 interference demand, F (1, 49) = 7.461, p = .006. However, there were no other significant interactions between either positive or negative PANAS quartiles, N-1 WM demand, or three-way interactions with both N-1 WM demand and mood condition (See Table 4.4).

Additional tests were conducted to investigate the significant three-way interaction between PANAS negative quartiles, N-1 load demand, and N-1 interference demand. Follow-up independent sample t-tests were conducted to test reaction time difference between first (NQ1) and fourth (NQ4) quartiles of PANAS negative scores at each of the four levels of N-1 WM demand. Results indicated no significant differences between PANAS negative index quartiles at N-1 high load/N-1 high interference, t (53) =

.383, p = .703, N-1 high load/N-1 low interference, t (53) = .483, p = .631, N-1 low load/N-1 high interference, t (53) = .621, p = .537, or N-1 low load/N-1 low interference, t (53) = .015, p = .988. Due to the lack of difference scores between PANAS negative quartiles at each condition, no further conclusions can be made about the demonstrated three-way interaction.

No additional regression analyses were conducted due the null findings for any interactions between PANAS affect measures and N-1WM demand.

4.4 AIM 3: The Effect of Working Memory Capacity on Working Memory Performance Mediated by Mood Change

Simple regression models were designed to test the hypothesis that the magnitude of mood change due to the mood induction procedure would mediate the effect of participant's trait working memory capacity (WMC) on performance on the delayed-recognition working memory task. Mood change was calculated as the absolute value of the difference between participants' pre-mood induction and post-mood induction SAM affect ratings. WMC was calculated as participants' OSPAN score and total percent accuracy as the measure of performance on the delayed recognition task. The four step mediation model procedure, as described by Baron and Kenny (1986), did not support the proposed hypothesis. Results from the first step indicated that participant's WMC did not significantly predict change in task performance accuracy, b < .001, t (87) = -.121, p = .904, R^2 = < .001, F (1, 87) = .015, p = .904. Results from the second step demonstrated that OSPAN scores also did not predict change in the mediation measure, mood-induction based affect change, b = .001, t (87) = .074, p = .941, R^2 <.001, F (1, 87) = .006, p = .941. Finally, in step three, with accuracy set as the criterion, both OSPAN score (*b* < .001, *t* (86) = .133, *p* = .895) and mood change (*b* = -.003, *t* (86) = .850, *p* = .398) did not predict significant change in performance on the delayed recognition task, R^2 = .009, *F* (2, 86) = .371, *p* = .691. As such, testing for significant decrease in the direct effect from WMC to task performance due to inclusion of the mediator (affect change) for step four was not conducted. In conclusion, results indicated that WMC does not predict significant change in task performance nor change in induced affect state. In addition, affect change does not significantly predict change in task performance. In sum, it may be suggested with confidence that, in the current study, the effect of WMC on WM task performance is not mediated by change in affect via the mood-induction procedure.

CHAPTER 5: DISCUSSION

The current study was designed to investigate three specific topics regarding the effect of positive and negative mood on WM performance. One, do differences in trait affect and induced mood revealed specific impairments in WM? Two, is there an interplay between trait affect, induced mood, and dynamic adjustments in cognitive control? And three, does baseline WM capacity predict change in emotion via active manipulation, and does this change have a subsequent impact on task performance?

Results successfully replicated previous finding, indicating that increased demand of both WM load and distraction interference on the delayed-recognition paradigm independently modulated WM performance (Jha & Kiyonaga, 2010). In addition, it was evident that the mood induction procedure was successful in eliciting the desired Happy, Neutral, or Sad affect states. Mood induction-based affect change was measured using the SAM affect rating scale (Bradley & Lang, 1994). However, it is important to note that subsequent analyses indicated that responses on the SAM affect scale were more indicative of participants' positive affect (vs. negative) state. As such, it can be concluded with greater confidence that the induction methods significantly changed participants' level of positive affect (PA); however, induction-based changes in negative affect (NA) is less clear.

There is strong evidence that positive and negative affect are independent mood states (Watson & Tellegen, 1985). The present study supported this view, as results from self-reported affect on the PANAS indicated that the correlation between positive and negative indices was small and non-significant. These results provided added support to the presented methods of investigating the effect of mood on performance independently for both positive and negative affect.

We first investigated the impact of PA on WM performance. Research has provided mixed evidence regarding the effect of PA on cognition (Martin & Kerns, 2012; Yang et al., 2013); however, we proposed that trait PA and induced Happy mood would independently have a salutary effect of performance. In addition, based on the work by Cools and D'Esposito (2011), it was hypothesized that there would be a significant interaction between trait affect and induced mood.

The present study confirmed our hypothesis, demonstrating that individuals varied in their sensitivity to induced positive mood. A significant interaction was evident between trait PA and one's induced mood state on overall WM performance, such that greater trait PA was associated with poorer performance among participants induced in to a high-positive mood. However, high trait PA was associated with greater WM performance if induced into a low-positive mood. Consequentially, participants who presented with low trait positivity benefited from being induced into a heightened positive state, while the performance of those with high trait PA were benefited when induced into a low positive state. These results suggested that both too much, and too little PA has a negative impact on WM performance.

These findings are consistent with the inverted-U-shape model presented by Cools and D'Esposito (2011). An essential feature of this model, with regard to WM performance, is such that individuals vary in their predisposed sensitivity to induced PA. Cools and D'Espositio (2011) discussed how this predisposed variability may be due to differences in baseline working memory capacity (Kimberg et al., 1997), one's genetic disposition to dopamine (DA) sensitivity (Slifstein et al., 2008), or also baseline activation of DA in the PFC (Zahrt et al., 1997; Cai & Arnsten, 1997). Essentially, those with high sensitivity incur a cost to WM performance with added stimulation, while those with low sensitivity experience benefit. The mediating variable between PA and WM in the Cools and D'Esposito model was the degree DA stimulation in the prefrontal cortex (PFC). The present study was not designed to include measures DA; therefore, there is no conclusive evidence to confirm or deny that the present findings are a direct representation of this DA-based model. However, there is some research to suggest that the effects evident in the present behavioral paradigm may have also been mediated by DA stimulation. There is evidence demonstrating an association between self-reported positive mood and DA activity (Ashby et al., 1999; Burgdorf & Panksepp, 2006). In addition, research by Salimpoor et al., (2011) has demonstrated that peak emotional experiences while listening to pleasurable music were associated with increased endogenous DA release. Taken together, there is evidence to support the possibility that self-reported PA in the present study was associated with DA activation and that listening to pleasant and actively up-regulating positive mood with music autobiographical memories acted as a behavioral DA agonist. However, caution should be taken in interpreting any direct connection between the present findings and the DA-based features of the Cools and D'Esposito's inverted-U-shaped model. The connection that can be made between these models is that the effect of added stimulation on WM performance is dependent on trait-based variability. In Cools and D'Esposito's model, trait variability and stimulation were specific to DA activity, while in the present study, variability and stimulation were specific to self-reported and behaviorally induced PA.

Positive affect was demonstrated to affect both cognitive demand features targeted in the delayed-recognition paradigm (i.e., maintenance & interference inhibition). Interference demand was attenuated with greater PA, while the effects of maintenance demand were in line with the presented trait PA-by-induced mood interaction. Results demonstrated that increased trait PA was associated with decreased interference effects in accuracy performance. In addition, the Happy mood condition had reduced interference demand effects in reaction time compared to Neutral and Sad. With regard to maintenance demand, the effect of PA was consistent with the interaction model, demonstrating increased demand among those with high trait PA and induced high positive mood as well as those with low trait PA and induced low positive mood.

These present findings provide added insight into the features of cognitive flexibility associated with PA, specifically, the ability to actively engage in or disengage one's attention on a visually presented stimuli. The current study demonstrated that PA was associated with greater disengagement of attention. This behavior is representative of affect-based differences between bottom-up versus top-down cognitive processing. Bottom-up processing is viewed as the tendency to base thoughts and actions on what is directly perceived or felt from in one's immediate environment (Kuhbandner et al., 2009). This processing is often associated with a narrowed focus of attention on specific features of visually presented images (Gasper & Clore, 2002). Bottom-up processing is more indicative of negative mood states (Kuhbandner et al., 2009). On the other hand, top-down cognitive processing is more detached from immediate environment (Clore & Huntsinger, 2007). Instead, thoughts and actions are processed in a more global manner (Gasper & Clore, 2002), based heuristics (Schwarz & Clore, 2007) and acquired schemas

(Bless et al., 1996). As such, greater top-down processing would be represented as decreased engagement or investment of one's attention in visually presented stimuli, and therefore, greater flexibility to switch attention to novel stimuli. Increased PA has been associated with greater top-down processing (Clore & Huntsinger, 2007), and it is this behavioral tendency that was represented in the present findings.

This view is consistent with the evidence provided by Dreisbach (2006). To review, Dreisbach (2006) demonstrated that those induced into positive mood states had difficulty to engage in and maintain information when it was advantageous to do so. However, because of this decreased engagement, participants had greater ability to flexibly switch attention to novel stimuli which resulted in improved performance on the flexibility-demand trials. Dreisbach (2006) concluded that maintenance and cognitive flexibility are antagonistic processes, and that those in positive mood states are tipped towards the direction of greater flexibility at the cost of maintenance ability. The present findings were consistent with this model. Individuals with high PA had poorer ability to actively engage in and maintain target images when the load demand was increased. However, this decreased engagement was also beneficial when processing the intermittently presented distractor images. Here, PA was associated with decreased interference effects, or greater ability to disengage one's attention from highly distracting information.

It also is important to also note the evidence for greater cost to maintenance demand among those with very low PA (low trait PA / induced low PA mood). While the benefits of PA on one's ability disengaging from distraction was represented in a more linear relationship, it appears that negative effects of PA on maintenance abilities is demonstrates a quadratic trend. As such, results suggest that both too-much and too-little PA has a deleterious effect on one's ability to maintain information.

Taken together, the present findings demonstrated that greater PA was associated increased top-down processing, which was represented as a cost when greater engagement was required to maintain high-load target information, but also as a benefit when required to disengage from highly distracting information. However, the presented interaction also indicated that both too-much and too-little PA was associated with greater maintenance demand effects. This data suggests that a moderate level of PA may assist individuals in their ability to engage attention on and maintain visual information.

The relationship between negative mood and WM performance demonstrated in the present study was not directly consistent with the preliminary hypotheses. Based on previous literature (Brose et al., 2012), we proposed that both trait NA and induced sad mood would have a deleterious effect on WM performance. Results indicated that induced Sad mood did not have a significant impact on working memory performance. In addition, greater trait NA did not predict change in either overall WM performance or the magnitude of maintenance and interference demand effects. However, there was a significant interaction between trait NA and induced mood condition. This interaction indicated that trait NA was associated with a greater interference demand effects in the Neutral condition, while this association was non-significant in both the Happy and Sad conditions.

The evidence that NA was either preserved or exacerbated in the Neutral condition, and removed in the Happy and Sad, was a surprising effect; however, it is hypothesized that this effect lies in the differences that may have existed between participants' experience of the Neutral mood induction procedure compared to Happy and Sad. One potential explanation for this result is that the Happy and Sad mood (vs. Neutral) conditions may have elicited greater online cognitive control in the service of achieving the prescribed mood. This increase in cognitive control for the two mood conditions may have made more control resources available during task engagement. A second reason may be that those in the Happy and Sad mood conditions experienced a more 'hot' or extreme emotion post-induction, compared to neutral, and that these 'hot' post-induction states may have more-effectively masked the impact of pre-task trait NA on performance. In addition, if the Neutral condition may have instead allowed participants with high trait NA an extended period of rumination. Research has demonstrated that the tendency to engage in ruminative thoughts is associated with NA (Moberly & Watkins, 2008). Also, actively engaging in rumination has been demonstrated to impair cognitive control abilities (Brinker et al., 2013). As such, the negative effect of trait NA on WM performance in the neutral condition may have been due to rumination. However, no rumination measures were collect and the proposed hypotheses for this effect are speculative in nature. Additional research is necessary to replicate these findings and directly assess for the proposed phenomena.

Regardless of the direct cause for the interaction, it should be noted that the interference demand was most vulnerable to the impact of trait NA. This is consistent with the discussed literature on the limited attention capacity among those in negative mood states (Ellis & Ashbrook, 1988). An inherent feature of WM is that it is limited in capacity (Baddeley, 1992). On high interference trials, all presented images shared the same domain. In sum, this limited WM capacity may have been exhausted among those with high NA and limited attentional resources.

It is also important to note that there was minimal evidence in the present study demonstrating a main effect between mood induction groups on performance. Instead, the strongest effects of negative and PA on WM performance were demonstrated through the interaction between participants' trait affective and induced mood. Here, we propose two possible reasons that may account for these null results. One, the WM paradigm was demanding enough to elucidate the actual cognitive differences between mood conditions. Participant's average total accuracy performance was relatively high at 92.5% and demonstrated a moderate negative skew (Skewness index = -1.153), suggesting a potential ceiling effect in performance. Two, the cognitive demand features of the delayed-working memory task did not targeted the actual deficits inherent to induced mood. Future research would benefit from a delayed-recognition task with greater demand and experimental protocol including supplementary measures of cognitive control to test if change in cognitive abilities were truly elicited by induced mood, but not targeted in the delayed-recognition task.

The second aim of the present study was to investigate the effect of mood on WM demand-triggered dynamic adjustments in cognitive control. The present findings replicated some of the results from Jha and Kiyonaga, 2010. However, previous-trial based WM performance was not significantly moderated by induced mood, trait affect, or their interactions. To review, Jha and Kiyonaga, 2010 demonstrated in a similar delayed-recognition paradigm that both increased maintenance and interference WM demand triggered an up-regulation in cognitive control. This was evident in increased performance among participants following previous trial (N-1) high WM demand, compared to N-1 low demand. The present findings replicated Jha and Kiyonaga (2010)'s finding with respect to change as a function of in maintenance demand. However, participants in the present study performed worse following N-1 high interference demand, compared to N-1 low interference. These results demonstrated that WM interference demand acted as a cost to performance, opposed to the benefits evidenced in the previous study.

There are two differences in experimental methods between the present study and that conducted by Jha & Kiyonaga, 2010 that may have contributed to the disparate finding regarding performance based on N-1 interference demand. First, contrary to Jha and Kiyonaga (2010), the present study included a mood-induction procedure prior to the experimental task. It is possible that the features of cognitive control necessary to up-regulate in response to high interference demand were exhausted during the 10-minute induction procedure. Research has demonstrated that the active regulation of one's emotions comes at cost to cognitive resources (Richards & Gross, 2000) and also causes poorer performance on cognitive tasks (Scheibe & Blanchard-Fields, 2009). As such, the emotion regulation demand in the current experimental paradigm may have drawn from participants' limited cognitive control abilities compared to those in Jha and Kiyonaga (2010). The second difference in the present study was the inclusion of music playing throughout the experiment. The purpose of allowing music to play continually was to preserve participants' induced mood state throughout the task. However, research has demonstrated extraneous sounds may cause added interference demand on cognitive control (Cassidy & MacDonald, 2007). In sum, the costs in performance due to N-1 high interference demand may be the product of cognitive exhaustion, due to continuous regulation of both task-based and auditory interference.

In addition, the present findings provided additional support for the hypothesis proposed by Jha & Kiyonga (2010), that WM demand-triggered up regulation in cognitive control is not a domain-general mechanism, but rather independent to both maintenance and interference demand. Evidence form the present study supports this view, as demonstrated by the dissociable and antithetical behavioral responses evident between N-1 maintenance and interference demand-based performance.

The present findings also did not support the hypotheses regarding the effects of mood on N-1 based adjustments in performance. van Steenbergen and colleagues have been the primary investigators researching the effects of mood on dynamic adjustments in cognitive control. Their findings suggested that NA is associated with increased adjustments (van Steenbergen et al., 2010), and that the experience of PA in response to rewards attenuates these effects (van Steenbergen, et al., 2009). As such, it was hypothesized that the same effect of negative and positive mood would be evident in the present study. However, the effect of trait affect, induced mood, and their interaction presented no significant effects on N-1 demand-based performance. van Steenburgen demonstrated these effects of mood using exclusively conflict-based cognitive tasks (i.e., Flanker). In sum, it is possible that adjustments in cognitive control triggered by conflict are more susceptible to changes in affect, while WM-demand-based adjustments are not moderated by change in mood.

Overall, the results from the present study did not fully support the preliminary hypotheses. The effects of WM-demand based adjustments were replicated for N-1 load demand; however, high interference demand instead triggered a cost to performance. This discrepancy from Jha and Kiyonaga (2010) is likely due the discussed differences between respective experimental paradigms. In addition, contrary to previous research with conflict-based tasks, the present data suggests that WM demand-triggered performance adjustments are not modulated by one’s mood.

The third aim of the present study was to test the hypothesis that the effect of participants’ working memory capacity (WMC) on the delayed-recognition WM task performance was mediated by change in emotion due to the mood induction procedure. The results demonstrated no significant relationship between WMC and task performance or WMC and the magnitude of emotion change due to the induction procedure. In addition, participants’ magnitude of emotion change, pre-to-post mood induction, did not significantly predict task performance. Taken together, the results did not indicate a significant relationship between these three measures, nor a significant mediation model.

The lack of association between WMC and task performance was surprising; however, it may be due to the differences in cognitive demand elicited between tasks. Working memory capacity was tested using the OSPAN task (Turner & Engle, 1989). The OSPAN is primarily based on verbal working memory, requesting participants to remember a series letters and complete intermittent math problems. However, the present delayed-recognition task was strictly visual, and this difference may account for the lack of correlation between measures. In addition, the OSPAN is designed to measure the limits of one’s overall WM capacity, while the delayed-recognition task is targeted at specific cognitive control features of maintenance and interference inhibition. It was assumed that WMC would be associated with these independent control features; however, the current results do not support that hypothesis.

Schmeichel et al., (2008) also demonstrated that increased WMC was associated with greater emotion regulation abilities. This was demonstrated when asking participants to decrease their emotional response to both positive and negative stimuli. Based on these results, it was hypothesized that high WMC may also be associated with increased ability to up-regulate one's emotions towards a desired mood state. However, given the present null effects, it may be that WMC resources are better suited to down regulate one's response to externally evocative stimuli, instead of internally up-regulating one towards a desired mood state.

General Discussion

The current study was designed to test the effects of both positive and negative affect on working memory performance. The effect of positive mood on overall performance replicated an inverted-U-shaped model, demonstrating an interaction between trait PA and induced mood. The interaction indicated that trait PA predicted poorer performance among those induced into high positive mood states and predicted increased performance for those induced into low positive mood. Also, trait PA was associated with decreased interference effects across all mood conditions. These effects are representative of the costs and benefits of increased top-down processing and cognitive flexibility inherent to positive mood states. The effect of NA on WM performance was specific to the Neutral mood condition, and was associated with increased interference demand effects. Results demonstrated that the effect of NA on performance was masked in the Happy and Sad conditions, which may be due to the dissociable nature of these induction procedures compared to Neutral. Previous trial-based analyses indicated that both positive and negative affect do not significantly moderate WM-based dynamic adjustments. However, results also demonstrated that previous trial high interference demand triggered a cost to WM performance. This effect contradicts the evidence demonstrated by Jha & Kiyonaga, (2010), and is likely due the differences in experimental protocol between studies. Finally, WMC did not significantly predict change in emotion during the mood induction procedure or performance on the delayed-recognition task.

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Appendix: TABLES AND FIGURES

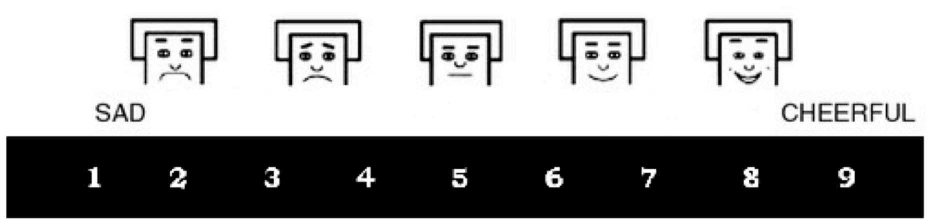
Table 2.1. Demographics.					
Total Sample *N* = 104					
	Age	*M* = 19.1	SD = 1.71	Rage = 17-29	
	Gender				
		Male	*n* = 45	43%	
		Female	*n* = 59	57%	
	Ethnicity				
		Asian	*n* = 13	13%	
		Black	*n* = 7	6%	
		Hispanic	*n* = 28	27%	
		White	*n* = 45	44%	
		American Indian or Alaskan Native	*n* = 2	2%	
		Other/Unknown	*n* = 9	8%	
Mood Groups					
	Happy *n* = 31				
		Age	*M* = 18.9	SD = 1.27	Range = 18-23
		Gender			
			Male	*n* = 10	32%
			Female	*n* = 21	68%
		Ethnicity			
			Asian	*n* = 2	7%
			Black	*n* = 2	7%
			Hispanic	*n* = 11	35%
			White	*n* = 11	35%
			American Indian or Alaskan Native	*n* = 1	3%
			Other/Unknown	*n* = 4	13%
		Handedness			
			Left	*n* = 3	10%
			Right	*n* = 28	90%
	Neutral *n* = 31				
		Age	*M* = 19.22	SD = 2.19	Range = 17-29
		Gender			
			Male	*n* = 14	45%
			Female	*n* = 17	55%
		Ethnicity			
			Asian	*n* = 5	16%
			Black	*n* = 2	7%
			Hispanic	*n* = 8	25%
			White	*n* = 16	52%
		Handedness			
			Left	*n* = 2	7%
			Right	*n* = 29	93%
	Sad *n* = 30				
		Age	*M* = 19.23	SD = 1.83	Range = 17-27
		Gender			
			Male	*n* = 11	37%
			Female	*n* = 19	63%
		Ethnicity			
			Asian	*n* = 4	13%
			Black	*n* = 3	10%
			Hispanic	*n* = 9	30%
			White	*n* = 12	40%
			Other/Unknown	*n* = 2	7%
		Handedness			
			Left	*n* = 2	7%
			Right	*n* = 28	93%
Note. 12 participants are not included in Mood Group Demographics: 10 participants did not complete Day 2 testing and 2 participants were excluded due to a performance on the delayed-recognition task 3 SD away from the mean.					

Table 2.2 Measure differences between those completed Day 1 measures in group or individual setting.				
Measure	Day 1 Individual (n = 37)	Day 1 Groups (n = 67)	Independent Sample t-test Statistic	p-value
CESD	M = 40.65 (6.04)	M = 39.03 (6.27)	t (102) = 1.277	.204
ERQ-reappraisal	M = 28.89 (5.95)	M = 30.04 (5.59)	t (102) = -.984	.328
ERQ-suppression	M = 15.35 (5.36)	M = 15.69 (5.07)	t (102) = -.316	.752
MCSDS	M = 16.14 (4.52)	M = 15.58 (5.0)	t (102) = .558	.578
PANAS Negative	M = 19.24 (5.47)	M = 18.49 (5.82)	t (102) = .643	.522
PANAS Positive	M = 35.86 (5.78)	M = 33.64 (8.02)	t (102) = 1.48	.141
PANAS Total	M = 55.11 (8.54)	M = 52.13 (10.37)	t (102) = 1.49	.140
STAI State	M = 50.46 (2.78)	M = 51.6 (2.89)	t (100) = 1.943	.055
STAI Trait	M = 54.38 (2.97)	M = 54.55 (3.14)	t (102) = -.275	.784
OSPAN Score	M = 48.11 (15.5)	M = 43.09 (15.98)	t (102) = 1.537	.128

Table 2.3 Musical Selection List.	
Happy	Citation:
Hubert Laws version of Bach's "Brandenburger Concerto"	Wood et al., 1990
Delibes "Coppelia"	Clark & Teasdale, 1985
Yanni "Once Upon a Time"	Trambokaolous, 1997
Neutral	
Chopin "Walz No. 12"	Wood et al., 1990
Reich "Variations for Winds, Strings, and Keyboards"	Martin & Mehta, 1997
Faure "Ballad for Piano and Orchestra, Op. 19	Albersnagel, 1988, Stober, 1997
Sad	
Prokofiev "Russian under the Mangolian Yoke" at half speed	Wood et al., 1990
Beethoven "Piano Sonata No. 14	Trambakolous, 1997
Albinoni, "Adagio"	Martin & Metha, 1997, Mechlenbracker & Hager, 1986

Figure 2.1. Self-Assessment Manikin (SAM; Bradley & Lang, 1994) for both affect and arousal.

A.



B.

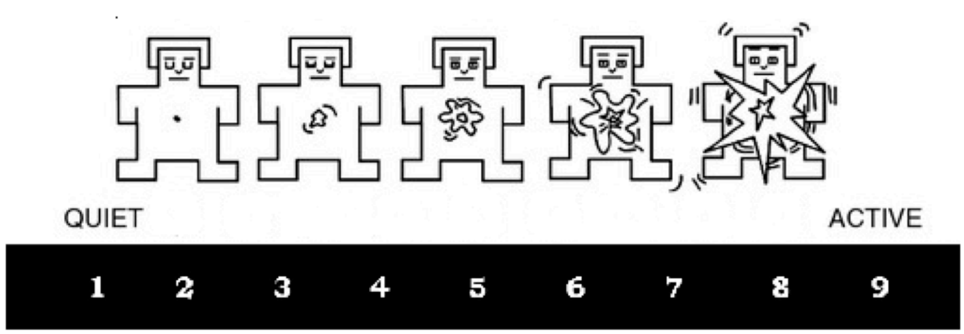


Figure 2.2. Delayed-recognition working memory trial sequence example.

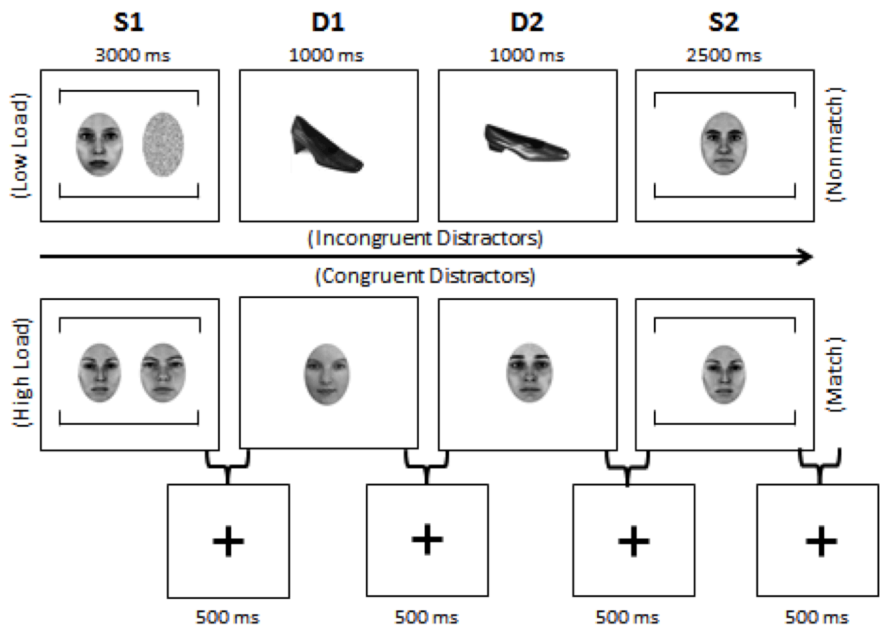


Figure 2.3. Mood Induction instructions transcript.

Before we begin the cognitive task I am going to ask you to get into a mood that makes you as [happy or sad] as you feel comfortable. You can do this by thinking about an event in your life where you felt especially (same mood word). I know that this may not be the easiest thing to do, but it is very important for our research.

I've done this a few times myself so I'll tell you a few things about it. I found that since I was the one asking myself to become (same mood word) by thinking about events in my own life, I was very much in control of the mood. I could intensify, lessen, and later even end the mood quite easily by changing my thoughts.

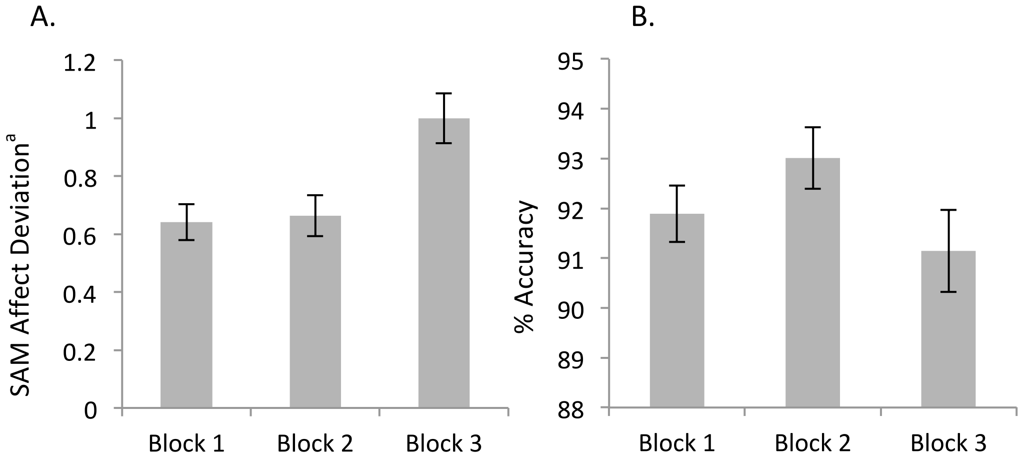
I'll begin by turning on some music that people usually find helpful for getting into mood that makes them feel (same mood word). While you are listening to the music, please think about a particular event from your past where you were especially (same mood word).

While you are listening to the music I'd like you to relive this event. When I did this, I thought about the time...(give a personal example). It is important to remember that the more detail you can re-create in your mind about the event, the more intensely you'll re-live that same feelings.

But I also want to reassure you that I will take time at the end of the session to make sure you are feeling normal again before you leave today. Remember that the goal is to feel as (same mood word) as possible for this short period of time. I know this may not be easy, but are you willing to try?

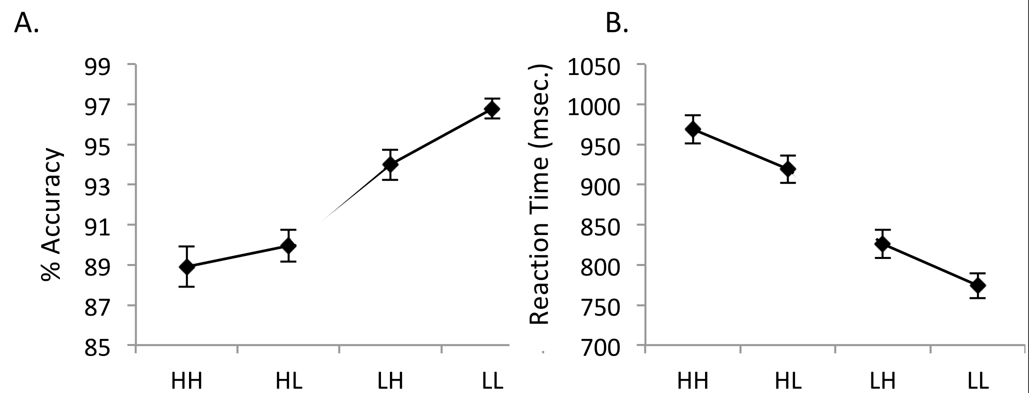
I'll leave you alone now with the music and your thoughts (dim room lighting). Please relax in the chair while you think about these events. I'll be coming back in 10 minutes to ask you to rate how you are feeling. Please try to stay focused on the events you are re-living. If you want to stop at any time, don't hesitate to tell me.

Figure 3.1. Experimental block differences in deviation from induced affect state and overall accuracy.



[a] Affect deviations calculated as the absolute value of the difference between post-induction SAM affect ratings and post-block SAM affect ratings.

Figure 4.1. Effect of WM demand on percent accuracy and reaction time performance.



Trial Demand:
HH = High Load/High Interference; HL = High Load/Low Interference
LH = Low Load/High Interference; LL = Low Load/Low Interference

Figure 4.2. Change in SAM Affect ratings due to mood induction procedure.

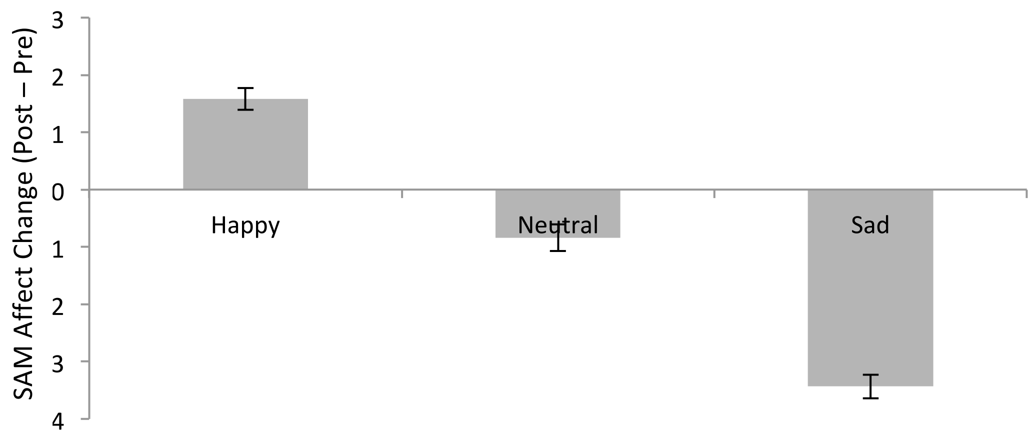
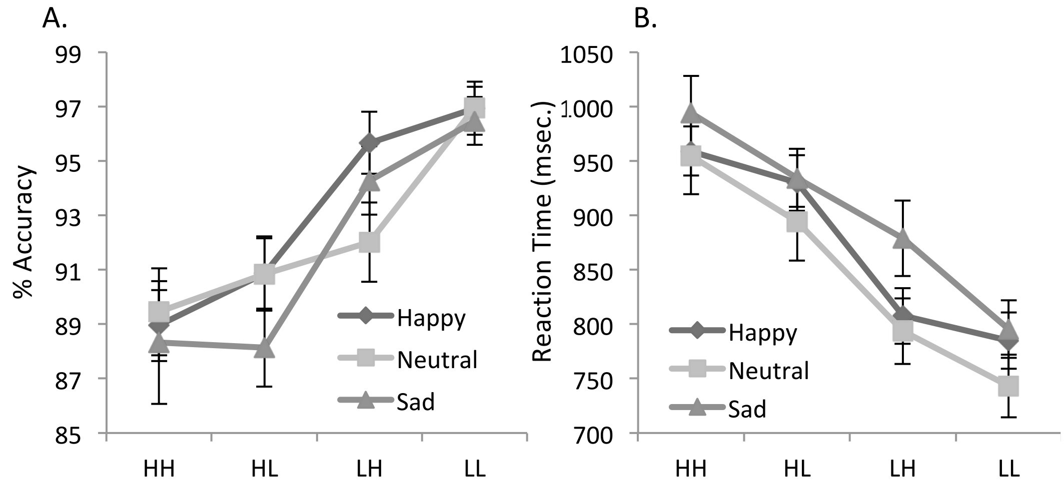


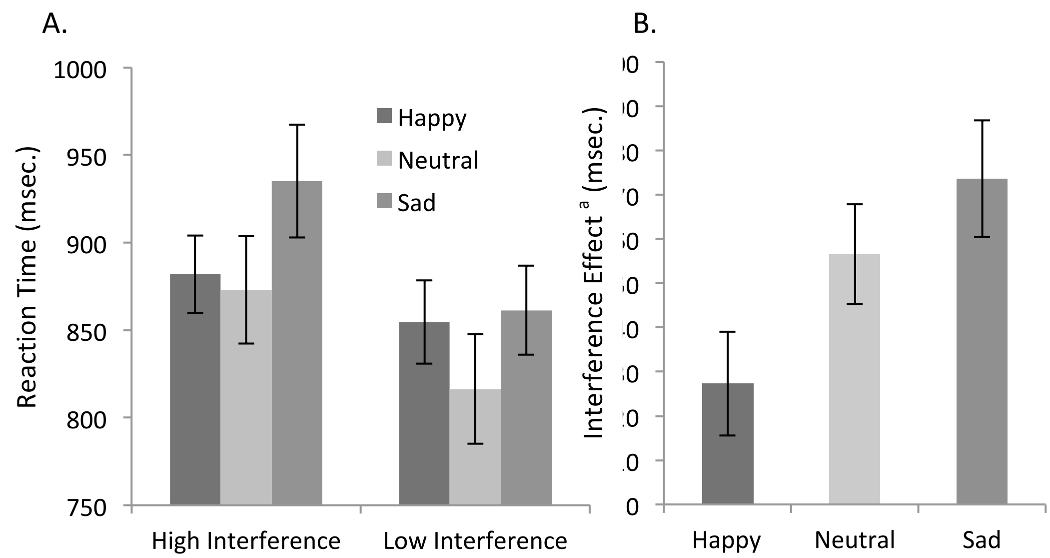
Table 4.1. One-Way ANOVA measure differences between mood conditions on each measure.		
Measure	Test Statistic	p-value
CESD	*F* (2, 89) = .048	.953
ERQ-R	*F* (2, 89) = .553	.577
ERQ-S	*F* (2, 89) = .078	.925
MCSDS	*F* (2, 89) = .725	.487
PANAS Negative Day 1	*F* (2, 89) = .718	.491
PANAS Positive Day 1	*F* (2, 89) = .380	.685
STAI- State	*F* (2, 89) = .438	.647
STAI- Trait	*F* (2, 89) = .398	.673
OSPAN- Score Index	*F* (2, 88) = .601	.551
PANAS Negative Day 2	*F* (2, 89) = 1.294	.279
PANAS Positive Day 2	*F* (2, 89) = 1.241	.294

Figure 4.3. Mood condition by WM demands interaction.



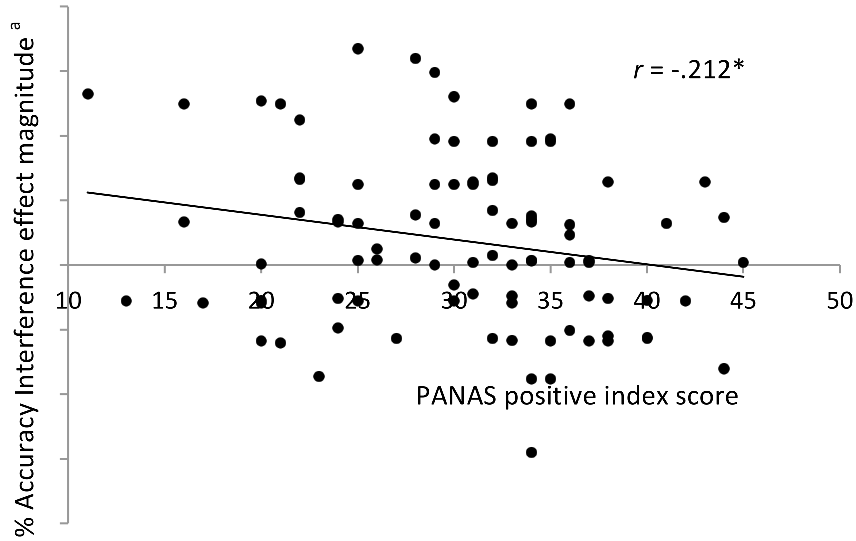
Trial Demand:
HH = High Load/High Interference; HL = High Load/Low Interference
LH = Low Load/High Interference; LL = Low Load/Low Interference

Figure 4.4. Mood condition by interference demand interaction.



[a] Interference Effect = (High Interference trial reaction time – Low Interference trial reaction time)

Figure 4.5. Correlation between PANAS positive index scores and the magnitude of interference effect on accuracy performance.



[a] Interference effect magnitude = (Low interference – High interference)

Table 4.2. Results from repeated measure analyses of variance (ANOVA) on percent accuracy and reaction time.

Effect:	Percent Accuracy				Reaction Time			
	F	df	p-value	Partial η^2	F	df	p-value	Partial η^2
Load	56.65	1, 91	<.001**	.384	302.36	1, 91	<.001**	.769
Interference	7.94	1,91	.006**	.080	49.11	1, 91	<.001**	.351
Load x Interference	2.268	1,91	.136	.024	.024	1, 91	.877	<.001
Mood	.553	2,89	.577	.012	.982	2, 89	.379	.22
Mood x Load	1.129	2,89	.328	.025	1.073	2, 89	.346	.024
Mood x Interference	.889	2,89	.415	.020	3.596	2, 89	.032*	.075
Mood x Load x Interference	1.156	2,89	.319	.025	.544	2, 89	.582	.012
PANAS Positive Quartiles (PQ)	.286	1,47	.595	.006	.147	1, 49	.127	.723
PQ x Mood	4.044	2,47	.024*	.147	.177	2, 49	.838	.007
PQ x Load	.225	2, 47	.637	.005	.992	1, 49	.324	.020
PQ x Interference	3.028	1, 47	.088	.061	.791	1, 49	.378	.016
PQ x Load x Interference	.514	1, 49	.447	.011	.669	1, 49	.417	.013
PQ x Mood x Load	2.404	2, 47	.101	.093	2.386	2, 49	.103	.089
PQ x Mood x Interference	.906	2, 47	.411	.037	1.636	2, 49	.205	.063
PQ x Mood x Load x Interference	.344	2, 47	.711	.014	2.296	2, 49	.111	.086
PANAS Negative Quartiles (NQ)	.319	1, 49	.575	.006	2.337	1, 47	.133	.047
NQ x Mood	.432	2, 49	.432	.034	.791	2, 47	.469	.033
NQ x Load	.492	1, 49	.486	.010	.266	1, 47	.609	.006
NQ x Interference	.085	1, 49	.772	.002	.015	1, 47	.903	<.001
NQ x Load x Interference	2.675	1, 49	.108	.052	.222	1, 47	.640	.005
NQ x Mood x Load	.792	2, 49	.459	.031	.266	1, 47	.609	.018
NQ x Mood x Interference	4.565	2, 49	.015*	.157	1.164	2, 47	.321	.047
NQ x Mood x Load x Interference	.684	2, 49	.509	.027	3.257	2, 47	.047*	.122

$p < .05$ *; $p < .01$ **

Figure 4.6. Accuracy difference between mood conditions among all first quartile PANAS positive and fourth quartile PANAS positive.

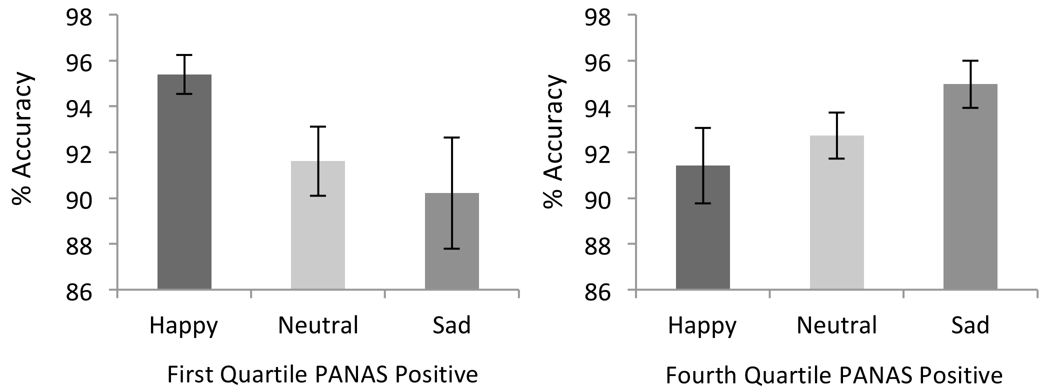


Figure 4.7. Accuracy differences between first and fourth quartile split by mood condition.

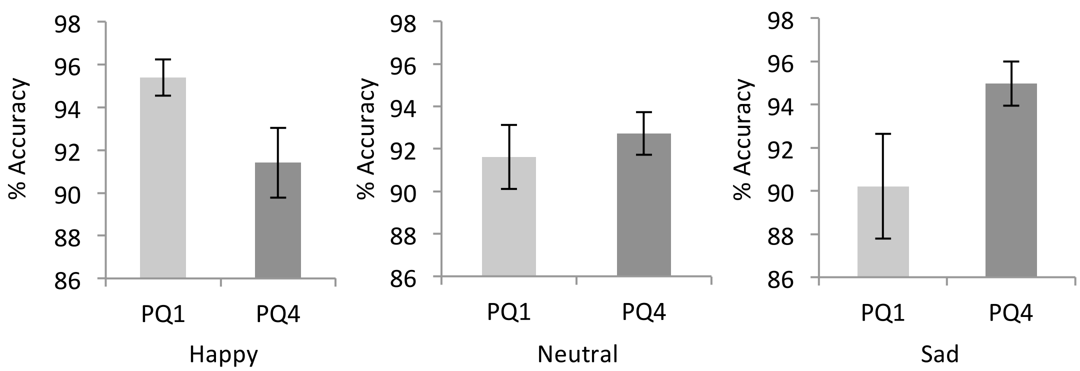
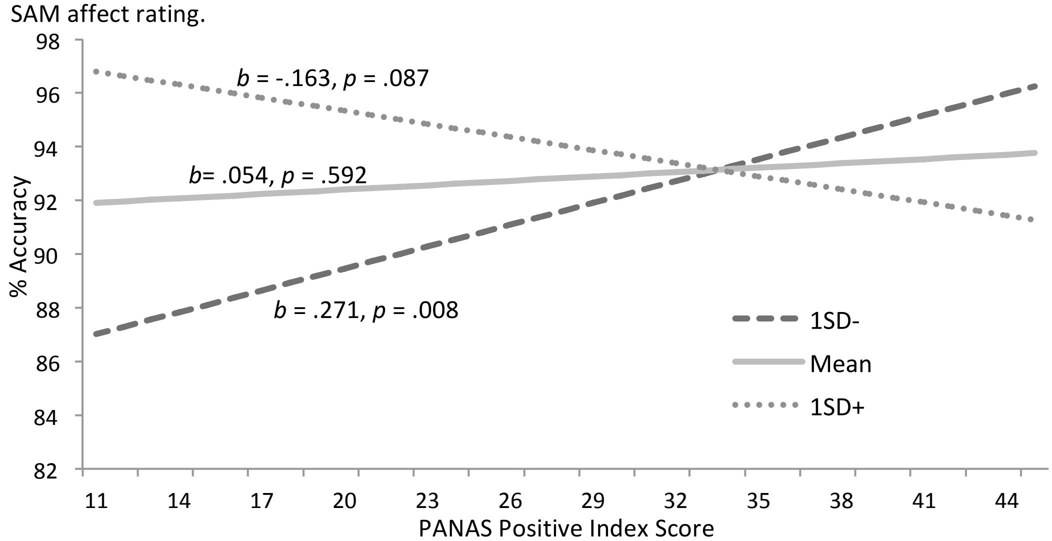
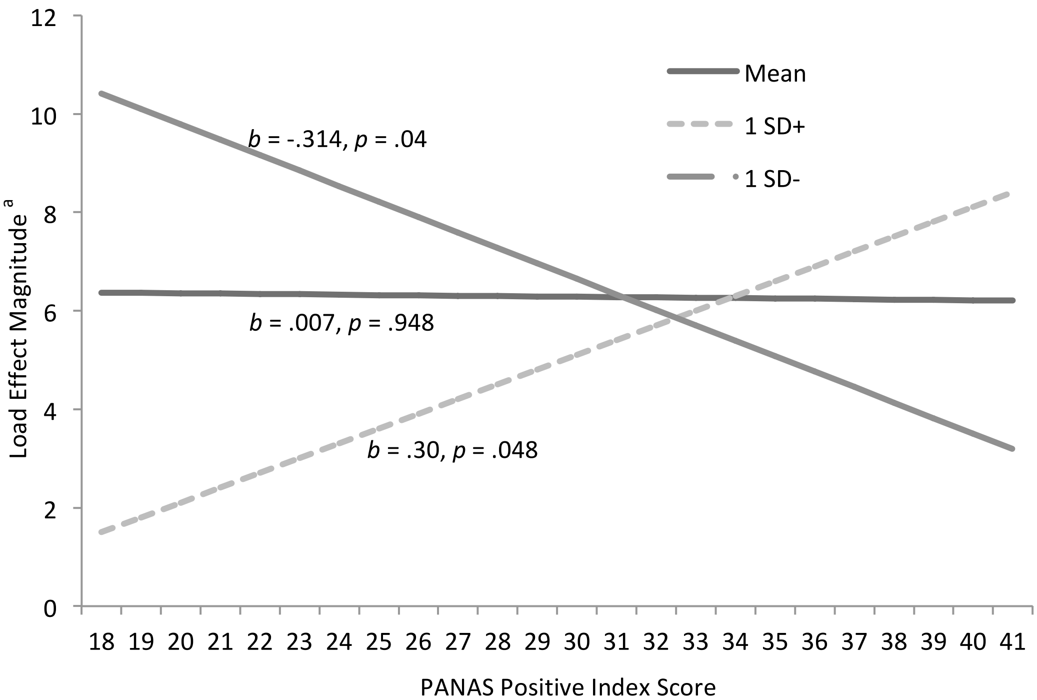


Figure 4.8. Regression model of the interaction between PANAS positive and post-induction SAM affect rating.



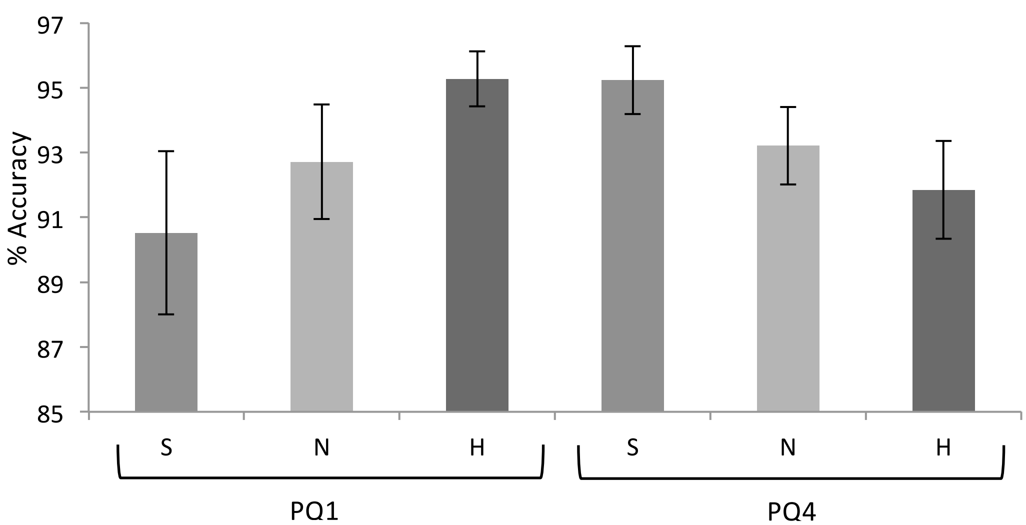
1SD- = Linear slope for post-mood induction SAM rating centered at 1 SD below its mean
Mean = Linear slope for post-mood induction SAM rating centered at mean
1SD+ = Linear slope for post-mood induction SAM rating centered at 1 SD above its mean

Figure 4.9. Regression model of the interaction between PANAS positive and post-induction SAM affect rating.



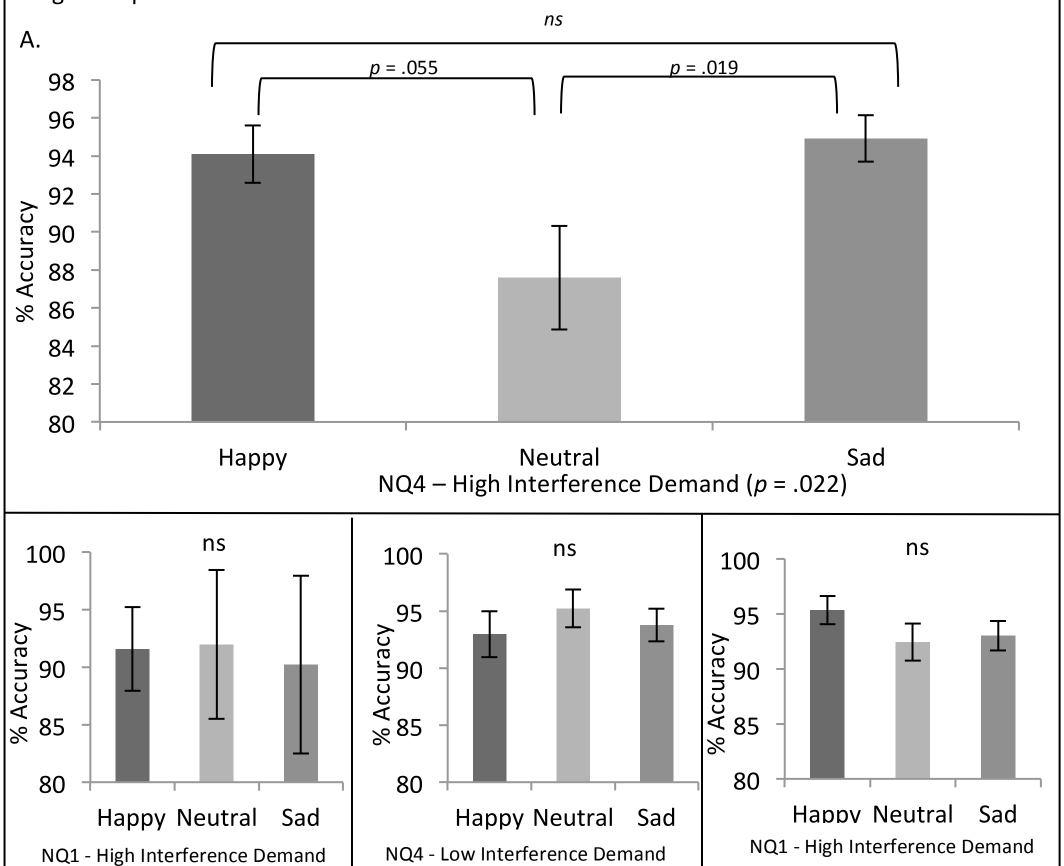
1SD- = Linear slope for post-mood induction SAM rating centered at 1 SD below its mean
Mean = Linear slope for post-mood induction SAM rating centered at mean
1SD+ = Linear slope for post-mood induction SAM rating centered at 1 SD above its mean
[a] Load effect magnitude = (Low Interference trial accuracy – High Interference trial accuracy)

Figure 4.10. Performance differences between the PANAS positive first and fourth quartile groups moderated by mood induction condition; resemblance of the inverted-U-shape (Cools & E'Esposito, 2010).



S = Sad condition N = Neutral condition H = Happy condition
PQ1 = PANAS positive first quartile group PQ4 = PANAS positive fourth quartile group

Figure 4.11. One-way ANOVA's between mood conditions, separated by levels of PANAS negative quartiles and Interference demand.



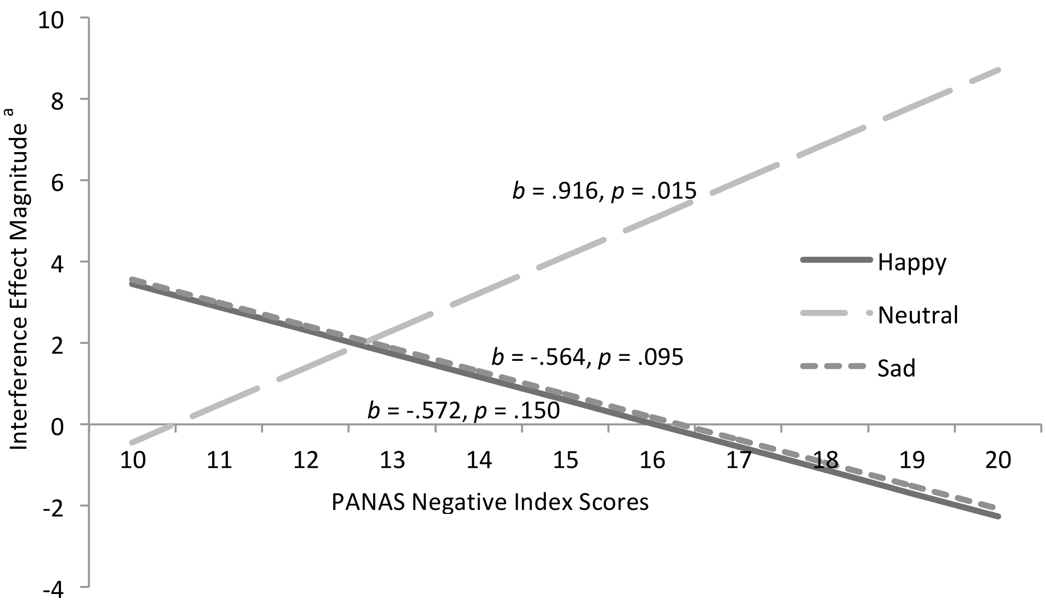
NQ4 = Fourth quartile of PANAS negative

NQ1 = First quartile of PANAS negative

Table 4.3. Output data for presented regression models.

Model:	Predictor	B	SE	Stdz B	t	p-value
A. Total % Accuracy on PANAS positive and post-induction SAM affect ratings, and their interaction	(Constant)	92.52	.484		191.1	<.001**
	PANAS Positive	.040	.067	.060	.592	.555
	SAM Affect Rating	.306	.218	.144	1.404	.164
	PANAS Pos. x SAM Affect	-.096	.032	-.308	-3.004	.003**
	Model Fit: R^2 = .107, F (3, 88) = 3.528, p = .018*					
Interaction follow-up analyses:	SAM centered @ +1 SD	-.177	.102	-.266	1.733	.087
	SAM centered @ +1.5 SD	-.286	.132	-.430	2.170	.033*
	SAM centered @ -1 SD	.257	.095	.386	2.703	.008**
B. Interference effect on PANAS positive and post-mood induction SAM affect ratings, and their interaction	(Constant)	1.874	.676		2.771	.007**
	PANAS Positive	-.187	.094	-.207	-1.994	.049*
	SAM Affect Rating	.091	.304	.031	.299	.766
	PANAS Pos. x SAM Affect	.042	.045	.099	.938	.351
	Model Fit: R^2 = .057, F (3, 88) = 1.765, p = .160					
C. Load effect on PANAS positive and post-mood induction SAM affect ratings, and their interaction	(Constant)	5.88	.768		7.669	<.001**
	PANAS Positive	-.007	.107	-.007	-.065	.948
	SAM Affect Rating	-.293	.346	-.088	-.8490	.398
	PANAS Pos. x SAM Affect	.136	.051	.279	2.678	.009**
	Model Fit: R^2 = .078, F (3, 88) = 2.470, p = .067					
Interaction follow-up analyses:	SAM @ +1SD	.300	.162	.289	1.849	.048*
	SAM @ -1SD	-.314	.151	-.302	-2.082	.040*
D. Interference effect on PANAS negative and post-mood induction SAM affect ratings, and their interaction	(Constant)	1.969	.710		2.773	.007**
	PANAS Negative	-.072	.227	-.065	-.319	.750
	SAM Affect Rating	.085	.316	.029	.268	.789
	PANAS Pos. x SAM Affect	.041	.096	.046	.424	.672
	Model Fit: R^2 = .005, F (3, 88) = .154, p = .927					
E. Pre-induction SAM Affect rating on PANAS positive and Negative index scores	Constant	6.087	.104		58.48	<.001**
	PANAS positive index	.083	.014	.516	5.78	<.001**
	PANAS negative index	-.054	.033	-.146	-1.64	.105
	R^2 = .292, F (2, 89) = 18.357, p < .001**					
F. Interference effect on PANAS negative and mood condition (Dummy coded), and their interaction	(Constant)					
	Happy Condition	-.572	.394	-.278	-1.452	.150
	Neutral Condition	.912	.369	.445	2.479	.015*
	Sad Condition	-.564	.334	-.274	-1.690	.095
	Happy vs. Neutral	18.78	7.51	1.361	2.500	.014*
	Sad vs. Neutral	18.80	7.26	1.351	2.588	.011*
	Happy vs. Sad	.019	7.33	.001	.003	.998
	Happy x Neutral	-1.488	.540	-1.482	-2.755	.007**
	Sad x Neutral	-1.479	.498	-1.615	-2.973	.004**
	Happy x Sad	.009	.516	.009	.017	.987
	Model Fit: R^2 = .132, F (5, 86) = 2.619 p = .030*					
p < .05*; p < .01**						

Figure 4.12. Regression model for the interaction between PANAS negative index scores and mood conditions on interference effect magnitude.



[a] Interference effect magnitude calculated by accuracy on low interference trials subtracted by accuracy on high interference trials

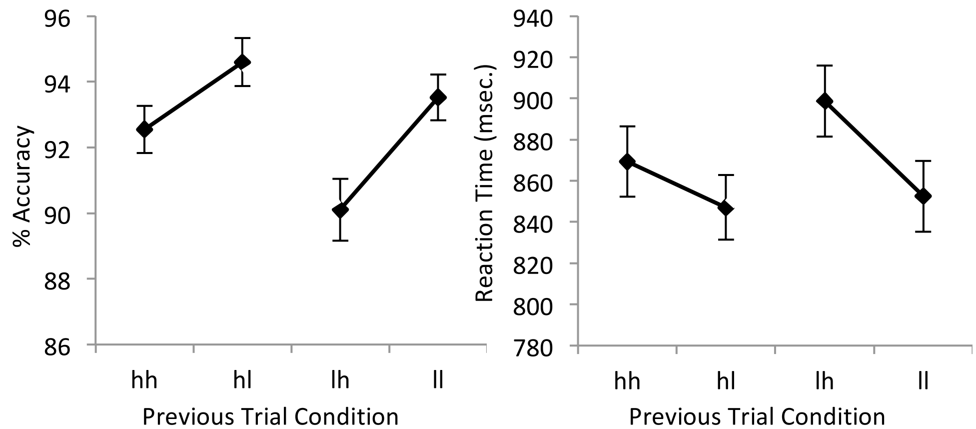
Table 4.4. Statistical results from repeated measure analyses of variance (ANOVA) on percent accuracy and reaction time based on previous trial working memory demand.

Effect:	Percent Accuracy				Reaction Time			
	F	df	p-value	Partial η^2	F	df	p-value	Partial η^2
Previous Load	6.631	1, 91	.012*	.068	5.244	1, 91	.024*	.054
Previous Interference	12.73	1, 91	.001**	.123	31.395	1, 91	<.001**	.257
Prev. Load x Prev. Interference	1.183	1, 91	.280	.013	3.591	1, 91	.061	.038
Mood	.594	2, 89	.554	.013	.757	2, 89	.472	.017
Mood x Prev. Load	.031	2, 89	.970	.001	.064	2, 89	.938	.001
Mood x Prev. Interference	.158	2, 89	.854	.004	1.034	2, 89	.360	.023
Mood x Prev. Load x Prev. Interference	.972	2, 89	.382	.021	.679	2, 89	.510	.015
PANAS Positive Quartiles (PQ)	.089	1, 47	.766	.002	2.108	1, 47	.153	.043
PQ x Mood	3.738	2, 47	.031*	.137	.828	2, 47	.443	.034
PQ x Previous Load	1.982	1, 47	.169	.040	1.148	1, 47	.290	.024
PQ x Prev. Interference	.120	1, 47	.730	.003	.044	1, 47	.836	.001
PQ x Prev. Load x Prev. Interference	.096	1, 47	.758	.002	1.532	1, 47	.222	.032
PQ x Mood x Prev. Load	2.263	2, 47	.115	.088	.012	2, 47	.988	.001
PQ x Mood x Prev. Interference	.033	2, 47	.968	.001	.004	2, 47	.996	<.001
PQ x Mood x Prev. Load x Prev. Interference	1.324	2, 47	.276	.053	.315	2, 47	.731	.013
PANAS Negative Quartiles (NQ)	.590	1, 49	.446	.012	.026	1, 49	.873	.001
NQ x Mood	1.044	2, 49	.360	.041	.311	2, 49	.735	.013
NQ x Prev. Load	.622	1, 49	.434	.013	.444	1, 49	.508	.009
NQ x Prev. Interference	1.984	1, 47	.165	.039	.082	1, 49	.776	.002
NQ x Prev. Load x Prev. Interference	.075	1, 49	.785	.002	7.461	1, 49	.006**	.132
NQ x Mood x Prev. Load	.351	2, 49	.705	.014	1.764	2, 49	.182	.067
NQ x Mood x Prev. Interference	2.488	2, 49	.093	.092	.141	2, 49	.869	.006
NQ x Mood x Prev. Load x Prev. Interference	1.064	2, 49	.363	.042	.380	2, 49	.686	.015

p < .05*; p < .01**

Figure 4.13. Percent accuracy and reaction time performance based on previous trial WM demand.

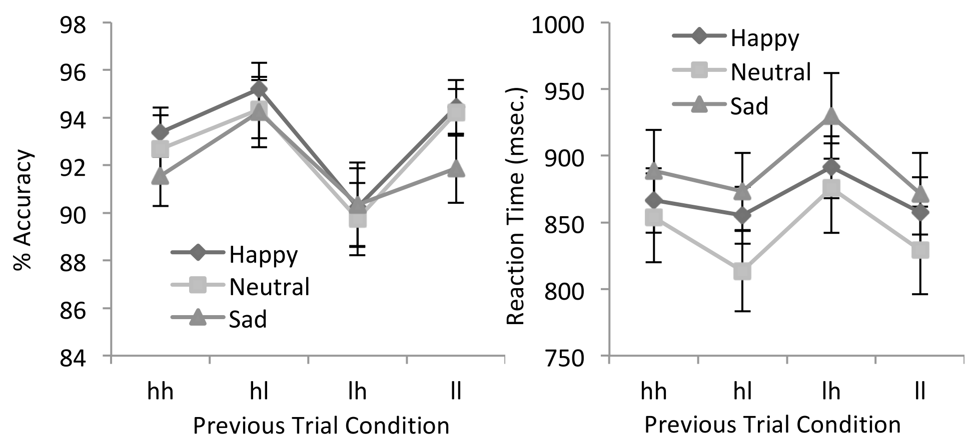
A. B.



hh = Previous trial High Load – High Interference **hl** = Previous trial High Load – Low Interference
lh = Previous trial Low Load – High Interference **ll** = Previous trial Low Load – Low Interference

Figure 4.14. Percent accuracy and reaction time performance based on previous trial WM demand.

A. B.



hh = Previous trial High Load – High Interference **hl** = Previous trial High Load – Low Interference
lh = Previous trial Low Load – High Interference **ll** = Previous trial Low Load – Low Interference