THE EMOTIONAL AND COGNITIVE FUNCTIONS OF COMFORT EATING

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ABSTRACT OF THE THESIS

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"Comfort eating" involves consuming highly palatable food in an effort to decrease negative emotion (Gibson, 2012). Despite existing empirical work demonstrating that comfort eating reduces negative emotion (Macht, 2008), recent research challenges these findings (Wagner et al., 2014) and raises questions about the functions of this behavior. To refine our understanding of comfort eating, the current study examined the functional impact of palatable food consumption on negative and positive emotion following stress, compared these effects to those produced by alternative coping behaviors, and examined the functional role of rumination. A community sample of 119 healthy men and women aged 18-31 years old underwent a 15-minute stress induction (Trier Social Stress Test; Kirschbaum et al., 1993), then engaged in 1 of 3 emotion regulation tasks: eating comfort food (M&Ms), using a stress relief ball, or sitting quietly. State emotion and rumination were assessed before stress, after stress, and after the randomized task. Repeated-measures MANCOVA analyses revealed that, while comfort eating significantly reduced negative emotion as expected, it was no more effective than doing nothing or using an alternative emotion regulation strategy. More promisingly, findings examining positive emotion demonstrated potential positive reinforcement functions of comfort eating. While both participants who used a stress ball and those who sat quietly experienced significant declines in positive emotion throughout the experiment, comfort eaters displayed steady levels of positive emotion. Findings also shed light on the role of rumination in comfort eating, as all emotion regulation tasks in this experiment were more negatively reinforcing and less positively reinforcing for high versus low state ruminators. Collectively, these findings suggest that comfort eating may be complexly reinforced through multiple pathways, including both positive

reinforcement and, particularly among high state ruminators, negative reinforcement. Given this, future research on comfort eating should examine the roles of positive emotion and rumination in understanding and treating comfort eating.

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I. Introduction

"I know the look of an apple that is roasting and sizzling on the hearth on a winter's evening, and I know the comfort that comes of eating it hot, along with some sugar and a drench of cream… I know how the nuts taken in conjunction with winter apples, cider, and doughnuts, make old people's tales and old jokes sound fresh and crisp and enchanting." –Mark Twain

Comforting properties have been ascribed to food throughout history, but it is only in the past decade that this relationship has been empirically tested. "Comfort" eating describes eating highly palatable food (e.g. foods high in sweetness, fat or calories) to alleviate negative affect (Gibson, 2012). Though the goal of comfort eating is to reduce unpleasant emotion, habitual engagement in comfort eating has been linked to adverse health outcomes, including elevated cholesterol (McCann, Warnick & Knopp, 1990), increased abdominal obesity (Dallman, Pecoraro & la Fleur, 2005), cortisol hypo-responsivity (Tryon, DeCant & Laugero, 2013), and weight gain (Epel et al., 2004; Green, Wilkinson & Woods, 1992).

Despite these negative health consequences, implicit in the definition of comfort eating is the assumption that comfort eating can, in fact, reduce negative emotion (Gibson, 2012; Tomiyama, Dallman & Epel, 2011). In support of this notion, several studies have demonstrated that comfort eating can ease psychological and physiological distress (Macht, 2008; Macht & Mueller, 2007; Smith, Fillion, & Blass, 1990; Wallis & Hetherington, 2009). In one of the first explicit experimental tests of comfort eating, Macht and Mueller (2007) exposed participants to a sad film clip, and found that participants who ate chocolate after viewing the clip reported significantly greater improvements in mood than those who only drank water. These data suggest that eating can provide immediate negative emotional reinforcement. This outcome is also supported

by studies demonstrating that foods high in sweetness (Smith, Fillion, & Blass, 1990) and fat (Dallman et al., 2003) have physiologically calming effects (Macht, 2008).

However, recent research challenges these findings, calling the emotion regulation function of comfort eating into question (Wagner, Ahlstrom, Redden, Vickers & Mann, 2014). In a 2014 study, Wagner and colleagues found that normal eaters who received their preferred comfort food (e.g., chocolate or cookies) after watching a sad film clip did not report significantly different levels of negative emotion than participants who received no food (Wagner et al., 2014). The finding that comfort food was no better than time at improving mood suggests that comfort eating may not be an effective method for regulating emotion. However, this study tested the effects of participants' unstandardized, preferred comfort foods rather than a standardized type of food, and it did not compare the effects of comfort food with alternative, non-food emotion regulation strategies. This study also focused primarily on the role of negative mood in driving comfort eating, and did not examine the potential role of positive emotion in reinforcing comfort eating. Given mixed findings on comfort eating and the overall lack of empirical work in this area, additional research is necessary to determine the functional impact of comfort eating on emotion.

Stress as an Antecedent of Comfort Eating

One common precipitant of negative emotion and concomitant comfort eating is stress, defined here as an environmentally distress-inducing disruption to the body's homeostasis (Dallman et al., 2003; Rosmond, 2003; Tomiyama et al., 2011; Wansink et al., 2003). A majority of U.S. adults report high levels of daily stress, with 63% of adults

in a recent national survey indicating that stress has a negative impact on their physical and mental health (APA, 2013). Stress exerts harmful effects on health through multiple pathways, increasing risk for cardiovascular disease and chronic pain (Steptoe, 1991), elevating global negative affect (Macht, 2008), and altering health behaviors like food intake (Zellner, Loaiza, Gonzalez, Pita, Morales, Pecora & Wolf, 2006).

The effects of stress on food consumption may be particularly harmful, as stress disrupts normal eating patterns and can increase risk for overeating and weight gain (Greeno & Wing, 1994; Korkeila, Kaprio, Rissanen, Koshenvuo, & Sörensen, 1998; Stone & Brownell, 1994). In naturalistic studies, stress precedes episodes of comfort eating in normal eaters (Stone & Brownell, 1994) and binge-eating in individuals with binge-eating disorder (BED) and bulimia nervosa (BN; Goldfield, Adamo, Rutherford & Legg, 2008). In one study using ecological momentary assessment (EMA), wherein participants complete self-report assessments multiple times daily as they go about their normal lives, daily hassles were associated with greater snack intake in normal eaters (Conner, Fitter & Fletcher, 1999). In fact, stressed individuals report increasing consumption of high-calorie foods even in the absence of homeostatic hunger (Rutters, Nieuwenhuizen, Lemmens, Born, & Westerterp-Plantenga, 2009). Considering these links between stress and non-homeostatic food intake, it is unsurprising that over time, stress is also associated with weight gain in college students (Epel et al., 2004; Serlachius, Hamer & Wardle, 2007) and adults (Block et al., 2009; Korkeila et al., 1998).

Stress promotes changes not only in the quantity of food consumption, but also in the quality of foods that are consumed. Stress promotes selective intake of specific foods (Cartwright, Wardle, Steggles, Simon, Croker, Jarvis, 2003; Steptoe & Wardle, 1998),

particularly foods high in sweetness (Oliver, Wardle & Gibson, 2000; Pecoraro, Reyes, Gomez, Bhargava & Dallman, 2004), fat (Cartwright et al., 2003), calories (Wallis & Hetherington, 2009), and/or convenience (Steptoe, Lipsey & Wardle, 1998). Stress is also linked with lower intake of healthier, nutrient-dense foods that are rich in vitamins and minerals, like fruit and vegetables (Mikolajczyk, Ansari, & Maxwell, 2009). Together, this can lead to a diet that is low in nutrients and high in calories, sugar and fat.

Given these stress-induced changes in quantity and quality of food consumption, stress-related eating confers significant health risks that may heighten all-cause mortality risk (Kim, Yang, Kim, & Lim, 2013). Health consequences include elevated body mass index (BMI; Laitinen, Ek, & Sovio, 2002), obesity (Cawley & Meyerhoefer, 2011), and the development of metabolic syndromes (Rosmond, Dallman & Bjorntorp, 1998; Rosmond, 2003). Results from three studies demonstrate that during periods of high academic or work stress, comfort eaters display greater calorie and sugar intake, elevated cortisol and nocturnal insulin levels, and more weight gain than those who do not comfort eat (Epel et al., 2004; McCann, Warnick & Knopp, 1990; Kim, Yang, Kim, & Lim, 2013). Given that stress-induced comfort eating confers significant risks to psychological and physical health, it is important to develop a more precise understanding of the functions and underlying mechanisms of comfort eating behavior.

Who Engages in Comfort Eating? Individual Variability and Moderating Factors

Though acute stress undoubtedly produces changes in food consumption, this effect appears to differ based on individual characteristics, with a subset of individuals reducing food intake and a subset increasing food intake after stress (Macht, 2008; Gibson et al.,

2012.) Though the precise breakdown is highly variable across studies, on average 48% of individuals reduce food intake after stress, 30% increase food intake, and a small minority experience no change (Dallman et al., 2003; Epel et al., 2004; Kandiah, Yake & Willett, 2008; Wallis & Hetherington, 2009). This effect has also been demonstrated in data from two naturalistic studies in normal eaters; on high stress days, 28%-39.7% of individuals reported increasing food intake and 60.3%-72% reported decreasing food intake (Stone & Brownell, 1994; Wallis & Hetherington, 2009).

Based on the physiological effects of stress, one might expect stress to unilaterally reduce appetite, as stress spikes blood glucose levels and inhibits digestive processes, changes that signal satiety (Heatherton, Herman, & Polivy, 1991; Selye, 1950). These physiological effects reveal a moderator of comfort eating behavior: the intensity and magnitude of the stressor. During intense acute stressors (e.g. car accident, surgery), physiological effects are potent, and food intake is reliably suppressed (Greeno & Wing, 1994). However, in the midst of moderate everyday stressors (e.g. traffic, project deadlines) physiological effects are milder, and food intake is more commonly increased (Conner, Fitter & Fletcher, 1999; Macht, 2008).

Engagement in comfort eating is also moderated by gender, with women reporting more engagement in comfort eating than men (Gibson, 2012; Wansink et al., 2003). Women and men also report different comfort food preferences when stressed, with women preferring easily available, energy dense snack foods and men typically preferring hot meal foods (Wagner et al., 2014; Wallis & Hetherington, 2009; Wansink et al., 2003). Men are also more likely to initiate comfort food intake in response to positive

emotion, while negative emotion is more often a trigger for women, who also experience more post-consumption feelings of guilt (Dube et al., 2005; Gibson, 2012).

Finally, it is also essential to differentiate comfort eating from related eating behaviors, particularly clinical binge eating. Binge-eating involves consuming an objectively large volume of food in a short time frame, feeling out of control and unable to stop eating during the episode, and feeling guilty and/or distressed afterwards. In contrast, comfort eating can occur with either large or smaller amounts of food, and feelings of dyscontrol, guilt and distress are either absent or mild (Gibson, 2012). Binge-eating is also a clinically significant behavior, being a part of many eating disorders, whereas comfort eating occurs outside of clinical populations and is not necessarily indicative of an eating disorder (Gibson, 2012).

Comfort Eating as a Strategy for Regulating Emotion

Though many stress reduction tools exist, there is a growing body of evidence that many behaviors can be used to regulate negative emotions (Selby, Anestis, & Joiner, 2008). One behavioral strategy for regulating stress and concomitant negative emotion may be comfort eating (Block et al., 2009; Torres & Nowson, 2007). Data from naturalistic studies show that eating behavior is prompted by negative emotional experiences in everyday life (Macht, Haupt, & Ellgring, 2005; Macht & Simons, 2000; Macht, 2008), and studies from human and animal research suggest that eating comfort foods may regulate emotion, though the effects are often short-lived and do not help resolve the initiating stressor (Gibson & Green, 2002; Kassab et al., 2012; Macht & Mueller, 2007; Ulrich-Lai & Ryan, 2014).

In one such study, Kassab and colleagues (2012) demonstrated that a sweet solution was significantly more effective than a placebo control at promoting physiological calm and reducing the incidence and duration of crying in infants who were being immunized (Kassab et al., 2012). In a meta-analysis of 14 studies of this effect in infants, crying in those given sucrose occurred less frequently, and when it did, it lasted 12 seconds less on average than for infants not given sucrose (see Harrison et al., 2010 for review). In rats given sucrose, the physiologically relaxing effects of sugar consumption did not occur when the sucrose was delivered gastrically, which controls for effects of taste, versus orally (Ulrich-Lai et al, 2010). This suggests that palatable taste and the process of consumption, versus macronutrient content alone, may drive the comforting effects of food (Ulrich-Lai & Ryan, 2014).

In adults, foods high in carbohydrates have also been found to produce similar soothing effects, with adults reporting greater sleepiness and calm after carbohydrate-rich meals versus protein-rich meals (Gibson & Green, 2002; Spring et al., 1983). More recently, Macht & Mueller (2007) found that participants who consumed chocolate had significantly lower negative mood than those who did not consume food, though the effect only persisted for 3 minutes (Macht & Mueller, 2007). These data suggest that comfort eating may have immediate anxiolytic effects that, although short-lived, may be effective enough to reinforce the behavior (Gibson, 2012; Green & Gibson, 2002).

It has also been proposed that comfort eating is reinforced by the long-term effects that eating has on the body's stress response (Adam & Epel, 2007; Dallman et al., 2003). In her biological model of comfort eating, Dallman and colleagues (2003) propose that stress-induced consumption of high-fat and high-calorie foods reduce the body's

hypothalamtic-pituitary-adrenal (HPA) axis response to stress over time by increasing visceral and abdominal adiposity, a change that blunts cortisol reactivity (Dallman et al., 2003). By down-regulating the body's stress response, habitual engagement in comfort eating may reduce long-term reactivity to stress (Dallman et al., 2003). This theory is supported by the research of Tomiyama and colleagues (2011), who demonstrated that women who reported high levels of chronic stress had dampened levels of cortisol over the course of the day, in response to an acute stressor, and in response to steroid administration (Tomiyama et al., 2011). The high stress group also reported more emotional eating and consumed more calories in response to an acute stressor (Tomiyama et al., 2011). Together, these results suggest that over time, coping with stress through comfort eating may reduce physiological reactivity to stress, providing long-term reinforcement of the behavior (Dallman et al., 2003; Tomiyama et al., 2011).

In contrast, other studies suggest that comfort eating may not be effective in regulating emotion. Across two self-report studies, participants who reported engaging in comfort eating did not report significantly reduced negative emotion while eating (Polivy, Herman & McFarlane, 1994) or immediately afterwards (Polivy & Herman, 1999). In a more recent investigation, Wagner and colleagues (2014) examined whether chocolate consumption prior to a mood induction would reduce the incidence and duration of negative mood elicited by a sad film clip. Results indicate that those who ate chocolate prior to the sad film experienced significantly less negative emotion than those who consumed nothing, but importantly, this effect was also true for participants who received chocolate but were instructed not to eat it. Eating chocolate and receiving chocolate had comparable protective effects against the development of negative mood, suggesting that

food consumption itself may not regulate emotion or confer protective mood benefits (Wagner et al., 2014). However, this study used a sad film clip to induce negative mood, and while this strategy is well-validated, it may lack personal salience. Noting that the ego-salience of stressors can impact subsequent eating behavior, with more ego-threatening stressors eliciting more eating, the use of a sad film clip in this study may have elicited negative mood that is not personally relevant, and therefore relatively repairable (Heatherton, Herman & Polivy, 1991). To enhance generalizability of laboratory findings to the real world, it is important to test the functions of comfort eating following a personally salient stressor, such as the modified Trier Social Stress used in the current study.

The Potential Role of Rumination in Comfort Eating

Given mixed findings concerning the impact of comfort eating on emotion, it is also important to evaluate other moderators of comfort eating effects, such as the potential cognitive functions of the behavior. To date, little research has examined the cognitive response to comfort eating with empirical methods, and one particularly promising cognitive response to examine may be rumination. Rumination is characterized by repetitious and self-critical thoughts that focus on troubling problems and emotional experiences without culminating in productive solutions. It is linked with diverse negative emotions, and is particularly pernicious because it heightens and prolongs negative emotion (Gerin et al., 2012; Macht, 2008; Nolen-Hoeksema & Morrow, 1991; Nolen-Hoeksema, Wisco & Lyubomirsky, 2008). Rumination may be important to examine in the context of comfort eating because several theorists have proposed that

distraction from aversive rumination may motivate disordered eating behaviors (Heatherton & Baumeister, 1991; Selby et al., 2008). Given that rumination is associated with increased stress (Gerin et al., 2012), a precipitant of comfort eating, and disordered eating (Cowdrey & Park, 2012), this study considered the role of rumination.

To understand rumination's potential function in comfort eating, it is important to understand rumination's bi-directional relationship with stress, an antecedent of comfort eating. Stress is both a precursor and byproduct of rumination (Gerin et al., 2012), a cycle that may be particularly relevant in motivating comfort eating. First, experiencing acute stress can prompt and increase engagement in rumination (Gerin et al., 2012; Johnson, Key, Routledge, Gerin & Campbell, 2014). While this effect occurs after the direct experience of stress, even *imagining* or remembering a stressful event can induce rumination regardless of how far in the past the event occurred, multiplying potential instances of stress-induced rumination (Gerin et al., 2012). Neuroscientific research may explain this effect, revealing that elevated stress inhibits activity in cortical brain regions linked to planning and emotional control (Tryon, Carter, DeCant & Laugero, 2013), inducing disinhibition that heightens engagement in rumination (Gerin et al., 2012). These stress-induced changes interfere with dieting efforts (Calu et al., 2013) and increase comfort eating in normal eaters (Gerin et al., 2012; Groesz et al 2013; Ulrich-Lai & Ryan, 2014; Yeomans & Coughlan, 2009). One possible explanation is that stress and rumination drain inhibition and cognitive resources, increasing risk for comfort eating.

Further, stress is also a byproduct of rumination, as rumination leads to heightened and prolonged physiological stress responding (Johnson, Key, Routledge, Gerin & Campbell, 2014). In fact, rumination prompts physiological stress responses that are not

functionally different from the level of activation that occurs during the actual stressor, and elevated rumination can lead to persistently heightened cardiac activity in daily life, during sleep, and up to a week after a stressor has ended (Gerin et al, 2012; Glynn, Christenfeld & Gerin, 2002; Ottaviani, Shapiro & Fitzgerald, 2011). In a recent study, Johnson and colleagues (2014) found that while acute stress elevated blood pressure in low and high trait ruminators comparably in the short term, in high ruminators only, blood pressure did not return to baseline even during sleep (Johnson et al., 2014).

Together, these findings suggest that the bi-directional relationship between stress and rumination may result in a positive feedback loop, wherein stress increases rumination, which heightens and prolongs stress progressively, resulting in so much stress and rumination to regulate that food is used to distract from rumination and calm physiological stress (Heatherton & Baumeister, 1991; Selby et al., 2008). In support of this theory, a ruminative response style confers greater risk for using maladaptive emotion regulation strategies (Heatherton & Baumeister, 1991; Nolen-Hoeksema, Stice, Wade & Bohon, 1997). In fact, ruminative processes are associated with disordered eating in clinical populations, such as binge-eating in bulimia nervosa (BN) and binge-eating disorder (BED), and with dysregulated eating in nonclinical populations (Gerin et al., 2012; Gibson, 2006; Nolen-Hoeksema et al., 1997).

Given these links, one function of comfort eating may be to distract from aversive self-focused rumination that is prompted by stress and negative emotion (Gerin et al., 2012; Gibson, 2012; Nolen-Hoeksema et al., 1997). The idea that eating may function to reduce self-focused rumination is not a new concept. In 1991, Heatherton & Baumeister proposed the “Escape Theory” of binge-eating, which postulates that food provides

potent physical sensations that shift attention toward the proximate environment, facilitating avoidance of negative self-focus or appraisal. In support of this notion, eating has been shown to distract from negative emotion (Macht, 2008; Spitzer & Rodin, 1983). Further, stressors that induce ego threats, but not physical pain, are linked with elevations in palatable food intake (Heatherton, Herman & Polivy, 1991; Lattimore & Maxwell, 2004; Oliver et al., 2000; Wallis & Hetherington, 2009). However, this relationship has been measured in the context of negative emotion, self-consciousness, and binge-eating, not in the context of rumination or stress-induced comfort eating.

A more recent model of dysregulated behavior, The Emotional Cascade Model (ECM; Selby et al., 2008), postulates that one function of binge-eating may be negative reinforcement to distract from rumination and relieve negative affect (Nolen Hoeksema et al., 1997; Selby et al., 2008). According to this model, stressful events trigger a positive feedback loop of negative affect, rumination, and distress that rapidly escalates, resulting in engagement in stress-reducing behaviors like binge eating. Though the model has not been applied to comfort eating, its theory is applicable and merits investigation. For example, in an effort to reduce emotional distress, distract from negative emotion, and interrupt the cycle of rumination, individuals may engage in comfort eating. Comfort eating produces physical sensations, including palatable taste and feelings of satiety that provide temporary relief from distress (Selby, Anestis & Joiner, 2008). Accordingly, distraction from this cycle of negative emotion and rumination may have a negative reinforcing effect that motivates comfort eating above and beyond the effect of the positive reinforcement provided by comfort foods. Empirically, emotional cascades have been linked to binge eating with both cross-sectional and longitudinal methods (Selby,

Anestis, & Joiner, 2008; Selby, Anestis, Bender & Joiner, 2009; Selby & Joiner, 2013). However, the literature remains unclear about the extent to which rumination and stress may play a functional role in driving comfort eating behavior.

Current Study

The current study aimed to refine our knowledge of comfort eating by examining the functional impact of palatable food consumption on negative and positive emotion following stress, comparing these effects to those produced by alternative coping behaviors, and discerning the role of rumination in comfort eating. To test these aims, healthy community participants completed a stress induction task and were randomized into 3 groups: a group that consumed sweet, high-calorie comfort food (e.g. M&Ms), a non-food intervention group that used an alternative emotion regulation strategy (e.g. squeezed a stress relief ball), or a control group that sat quietly. Negative emotion, positive emotion, and state rumination were self-reported before and after the stress induction and experimental manipulation to determine the impact of stress and our manipulations on emotion and rumination.

This study addressed many unanswered questions about comfort eating. First, both Wagner and colleagues (2014) and Macht and Mueller (2007) used sad films clips to induce negative emotion in their tests of comfort eating, but no studies to date have experimentally tested the comforting effects of food after a stressor. The current study also provided the first experimental test of stress-induced, as opposed to negative emotion-induced, eating. Additionally, this study built on prior research by comparing comfort eating to other strategies for regulating emotion.

Additionally, earlier studies focused primarily on comfort eating's impact on negative emotion, assuming that the main function of comfort eating is automatic negative reinforcement (Booth, 1994; Macht 2008). Though relief from negative emotions may be a function of comfort eating, few studies have examined the functional role of positive emotions in driving comfort eating. For example, eating tasty food may increase feelings of satisfaction, joy, and excitement, mood benefits that may play a significant role in reinforcing the behavior. Given our lack of knowledge about the emotional effects of comfort eating, greater attention to the role that automatic positive reinforcement may play in driving comfort eating is merited.

Finally, the literature has not examined the functional role that cognitive processes like rumination play in comfort eating. Multiple theorists suggest that comfort eating may function to distract from the aversive experience of rumination (Heatherton & Baumeister, 1991; Selby et al., 2009; Spitzer & Rodin, 1983). Emotional stress has been shown to prompt rumination, which then elevates and prolongs negative emotion, and eating may be used to distract from rumination, heightening positive emotion and reducing negative emotion (Gerin et al, 2012; Nolen-Hoeksema et al., 2008). This relationship has been examined in the context of binge eating (Heatherton & Baumeister, 1991), but not in the context of comfort eating.

Specific Aims and Hypotheses

To refine our knowledge of comfort eating, this study tested four aims and hypotheses.

Aim 1: To validate the effectiveness of the modified Trier Social Stress Test in increasing stress. Hypothesis 1: Participants will experience a significant increase in

negative emotion and decrease in positive emotion following the stress induction, relative to baseline.

Aim 2: To test the "comforting" effects of palatable food consumption. Hypothesis 2: Consumption of sweet nutrient-dense food (e.g., M&Ms) after stress will significantly decrease negative emotion (emotional negative reinforcement) and increase positive emotion (emotional positive reinforcement) relative to those in the no task control group.

Aim 3: To compare the emotional impact of palatable food with that of alternative emotion regulation techniques. Hypothesis 3: Individuals who consume sweet nutrient-dense food after stress will display significantly lower levels of negative emotion and higher levels of positive emotion compared to those in the stress ball distraction group.

Aim 4: To examine whether comfort eating may function to distract from stress-induced rumination (and concomitant negative emotion), first we will examine the impact of comfort eating versus other emotion regulation behaviors on momentary rumination. Hypothesis 4a: Consumption of sweet nutrient-dense food (e.g., M&Ms) after stress will significantly decrease momentary rumination relative to individuals in the no task and stress ball control groups. Hypothesis 4b: The effects of comfort eating on negative and positive emotion will be moderated by changes in momentary rumination, with larger decreases in rumination predicting larger decreases in negative emotion and increases in positive emotion.

II. Method

Participants

119 men and women were recruited from the local community for participation in this study. Individuals were considered for participation if they were 18 years or older and able to speak and read English fluently. Because this study aimed to examine the emotional functions of stress-induced eating, we recruited a healthy sample without physical conditions that could influence emotional responding to acute stress or to food consumption. For this reason, pregnant women, individuals with current major injuries or illnesses or severe obesity (BMI≥40), and those with food allergies that prevented M&M consumption were excluded from the study. Individuals with psychological disorders that could impact reactivity to stress or food consumption were also excluded, namely those with current major depression, an eating disorder, or a substance use disorder as defined by self-reported diagnosis or a qualifying score on relevant items of the Patient Health Questionnaire (Full PHQ; Spitzer, Kroenke, Williams & PHQ Primary Care Study Group, 1999). Those who self-reported any current psychological disorder or past psychotic disorder were excluded for similar reasons.

Of the 318 individuals who contacted us to participate in the study, 153 were excluded at pre-screen and 46 were excluded at baseline. Participants were 53 men and 66 women aged 18 to 31 years (M = 20.2, SD = 2.36). This racially diverse sample was 43% Asian, 28% Caucasian, 10% Hispanic/Latino, 8% African American, 8% Multiracial and 2% Other. The majority of participants were single (71%) and reported moderate-income status (76%).

Procedures

The Rutgers University Institutional Review Board approved all study procedures. Participants were recruited from flyers posted in local community, Rutgers campuses,

and online through sites like Craigslist. Interested individuals contacted a research assistant and received brief information about the study, along with a link to a pre-screen survey that assessed inclusion and exclusion criteria. Individuals who qualified to participate were contacted by a research assistant, who provided more information about the study and scheduled interested individuals for a 2-hour in-person visit.

Scheduled participants were asked to abstain from eating for 2 hours prior to their visit to induce baseline hunger per standard stress-induced eating study procedures (O'Donovan et al., 2012). Participants attended one 2-hour visit, wherein a research assistant provided an overview of the study, obtained written informed consent and confirmed participant adherence to food abstinence. Participants completed surveys assessing demographics, hunger, rumination and emotion on a laptop using Qualtrics Online Survey software (Qualtrics, 2014). During the study, participants were assessed for a variety of psychophysiological responses to the task (e.g., cardiac rate and output, blood pressure, electrodermal responding). However, because these variables are part of a larger ongoing project and are still undergoing cleaning and data reduction, they are not examined in the current research.

Participants then completed a 15-minute stress induction designed to increase stress. The protocol, modified from the well-validated Trier Social Stress Test (TSST; Kirschbaum, Pirke & Hellhammer, 1993), involved receiving intimidating instructions about upcoming math and speech tasks from a research assistant, sitting for 5 minutes to prepare for the tasks, completing 6 minutes of rigged serial subtraction, and delivering a 4-minute speech. The tasks were videotaped, and participants were told that their performance on subtraction and speech tasks would be evaluated by trained evaluators.

After stress, participants were left alone for 5 minutes, and based on randomization, received instructions to either: 1) eat a serving of plain M&Ms, 2) use a squeeze ball (i.e., a stress relief ball), or 3) sit quietly. Momentary rumination and emotion were assessed at 4 time points: after completing the informed consent, after the TSST instructions are given, after completion of the TSST, and after the emotion regulation task manipulation. Finally, participants completed surveys assessing food palatability and their experience of the stress and emotion regulation manipulations. BMI was determined by measuring participants' height and weight using an advanced digital scale and stadiometer. To minimize distress, participants were debriefed (e.g. informed of study aims and the rigged nature of the stress task), and were compensated $50 for their participation.

Measures

Baseline Measures

Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991). Trait rumination was measured using the RRS, a 22-item scale (**α**=.90) that assesses how often participants respond to depressed mood with thoughts or behaviors that passively dwell on negative mood and its potential causes and consequences. Participants rated their typical response style on a Likert scale ranging from 1 (almost never) to 4 (almost always), with a sample item being "Think about a recent situation, wishing it had gone better."

Other information. Participants provided demographic information regarding age, gender, ethnicity, and educational background. They also self-reported their food intake for the current day, as well as their current levels of hunger, fullness, satiety and food craving using Visual Analog Scales ranging from 0 ("I am not hungry at all") to 10 ("I have never

been more hungry). This measure was adapted from measures used by Schneider, Appelhans, Whited, Oleski & Pagoto (2010) and Flint, Raben, Blundell and Astrup (2000).

Momentary Measures

Positive and Negative Affect Schedule (PANAS; Watson, Tellegen & Clark, 1988). To assess state emotional experience, participants completed the PANAS scale at 4 time points: after completing the informed consent, after the TSST instructions were given, after completion of the TSST, and after the emotion regulation task manipulation. The PANAS contains 20-items that measure a range of current positive emotions (e.g. proud, interested, inspired) and current negative emotions (e.g. distressed, guilty, irritable) that are rated on a Likert scale from 1 (very slightly or not at all) to 5 (extremely). Negative emotion items were averaged to provide a total negative emotion score at each assessment, and the same procedure was followed for positive emotion items.

Momentary Rumination. Participants completed a 12-item *Momentary Rumination Assessment*, which asked them to rate thoughts that are occurring "right at this moment" on a Likert scale ranging from 1 (not at all true) to 10 (extremely true). This scale was constructed for the purposes of this research, and items were derived from previously validated measures of rumination, such as the CERQ (Garnefski et al., 2005) and the Response Styles Questionnaire (RSQ; Nolen-Hoeksema & Morrow, 1991), and was modeled after momentary measures of rumination used in experience sampling studies (Moberly & Watkins, 2008; Selby, Kranzler, Panza & Fehling, in press). Sample items are, "I am experiencing many thoughts about current personal problems" and "I am

experiencing many repetitive thoughts about how I am currently feeling." Items measure the construct of rumination by assessing self-reported repetitive quality of thoughts, content (personal problem), perceived ability to change, thought speed, past and future problems, and distress. This scale demonstrated adequate reliability, as participant scores on this scale at baseline (α=.82) were significantly correlated with scores on this scale after stress ((α=.87, r=.68, p<.01) and after completing the emotion regulation task ((α=.86, r=.70, p<.01). The scale also demonstrates construct validity, given that participant scores on this scale were significantly correlated with scores on the RRS, a well-validated measure of rumination, at baseline (r=.45, p<.01), after stress (r=.592, p<.01), and after completing the emotion regulation task (r=.58, p<.01).

Psychological Tasks

Stress Manipulation. The Trier Social Stress Test is a widely used and well-validated stress induction task (Kirschbaum, Pirke & Hellhammer, 1993). In the present study we used a modified version of the TSST that includes a 5-minute preparation period, a 6-minute serial subtraction task, and a 4-minute public speaking task. First, a research assistant provided task instructions, giving the participant 5 minutes to prepare for an arithmetic task and to prepare to deliver a speech about their strengths and weaknesses. Participants were knowingly videotaped throughout, and told that study personnel were watching and evaluating their performance from an adjacent room. After the 5-minute preparation period, participants performed a 6-minute serial subtraction task on a laptop using E-Prime software (Psychology Software Tools, Pittsburgh, PA, USA). The task was rigged for 40% maximum accuracy, and a loud, aversive noise sounded following

incorrect answers. Next, during a 4-minute public speaking task, participants delivered a speech about their strengths and weaknesses in front of a video camera. Throughout these procedures a research assistant stood behind them and watched their performance, instructing them to "move more quickly" or "focus on their weaknesses" at 30-second intervals. Lasting 15 minutes total, the task was comparable to stress inductions that have successfully induced stress in undergraduates when used by Zorawski, Blanding, Kuhn, & LaBar (2006) at Duke University. This group, who verified the ability of this task to increase stress by measuring cortisol before and after the stress induction, found that this task significantly increased cortisol levels in undergraduates ($p<.001$). Importantly, the task also increased cortisol levels significantly more than an alternative stressor task, which did not involve a psychosocial stress component (Zorawski, Blanding, Kuhn, & LaBar, 2006). The TSST has been used to elicit stress in numerous studies related to comfort eating (O'Donovan et al., 2012; Tomiyama et al., 2011; Tryon, DeCant & Laugero, 2013).

Emotion Regulation Manipulations. Following completion of the stress induction, participants were left alone in the study room for 5 minutes. Based on randomization, participants received instructions to complete one of three emotion regulation tasks: 1) consuming comfort food or "comfort eating," 2) squeezing a "stress relief" ball, or 3) "sitting quietly," a no-task control condition.

Participants in the "comfort eating" condition were given a 1.69oz serving of plain M&Ms (240kcal), and asked to consume the entire bag during the 5-minute period. Participants who were unable to complete the bag in that time were given an additional

minute to finish the serving. M&Ms, a standardized food, were chosen to test comfort eating in an effort to minimize confounding food-specific effects that may occur when using unstandardized foods (e.g. comfort food of choice) to test comfort eating effects. M&Ms were selected because foods high in sweetness have been shown to have immediate hedonic effects, reducing physiological stress (Kassab, Sheehy, King, Fowler & Foureur, 2012; Macht, 2008; Smith, Fillion & Blass, 1990). Chocolate in particular has been tested as a comfort food in previous studies of comfort eating, and has demonstrated efficacy in reducing the experience and development of negative mood (Macht & Mueller, 2007; Wagner et al., 2014). One serving was used because earlier studies of comfort eating have been criticized for using small portions (e.g. a fraction of a serving size), so in this study we provided a full serving size that could be comfortably consumed in a 5 minute time period (Macht & Mueller, 2007; Wagner et al., 2014). M&Ms are also a widely available convenience food that may be easily acquired by stressed comfort eaters on an impulse, enhancing the generalizability of this manipulation.

Participants in the stress relief ball distraction group were instructed to squeeze the "squeeze ball" during the 5-minute period. The term "squeeze ball" was used by research assistants, as opposed to "stress relief ball," in order to minimize the chance that placebo effects would occur in this group. This condition was designed to be an active, non-food stress reduction task. Considering that no studies have compared comfort eating to an active emotion regulation task, stress relief balls were selected based on their advertised effects, given that they are widely marketed as stress reduction tools. Though no empirical data has examined the psychological effects of using stress relief balls, lay knowledge suggests that the act of squeezing the ball may help divert attention from

thoughts and cognitions to the physical sensation of the ball, providing a physically distracting stimulus (see http://cognitusuk.com/why-do-stress-balls-work/ and http://www.livestrong.com/article/141645-what-are-benefits-stress-balls/ for examples). Stress relief balls are also affordable, easy to use, and widely available, making them a practical alternative emotion regulation strategy to disseminate.

Participants in the no task control group were instructed to sit and wait quietly during the time period. This condition is comparable to the no task condition in a comfort eating study done by Wagner and colleagues (2014).

Manipulation checks. Prior to debriefing, participants self-reported their stress level by answering open-ended, face-valid questions about their experience during the study (e.g. "Did you feel that this study stressed you out?") and during the task (e.g. "Did you feel stressed during the computerized and public speaking tasks?") to determine whether the stress induction was sufficiently aversive.

Manipulation checks were also conducted for the food exposure portion of the study. First, hunger was measured at baseline using a Visual Analog Scales ranging from 0 ("I am not hungry at all") to 10 ("I have never been more hungry), which was derived from two previously validated measures used by Schneider, Appelhans, Whited, Oleski & Pagoto (2010) and Flint, Raben, Blundell and Astrup (2000). Participants also completed a food palatability scale following food exposure, a strategy that has been used in studies of emotion-induced eating (Schneider et al., 2010) to control for effects of comfort food palatability on ratings of change in emotion. Using a Visual Analog Scale ranging from 0 ("very bad") to 10 ("very good"), participants rated the visual appeal, taste, smell and

palatability of 20 foods, including the food used in this manipulation, milk chocolate M&Ms. This scale was derived from a measure used by Flint and colleagues (2000).

Debriefing. At the end of the study visit, participants were informed of the purpose of the stress manipulation, as well as the fact that the task was rigged and designed to induce stress. Participants were asked whether the stress task was stressful for them, and participants received a list of referrals to a range of relevant psychological services.

III. Results

Preliminary Analyses

To examine the impact of food intake on positive and negative emotion after stress, data from 119 participants were collected at 3 time points: baseline (T1), following the Trier Social Stress Test (T2), and following the food manipulation (T3). Data were cleaned and coded using IBM SPSS Statistics Version 22.0. The dataset contained no missing data and the inspection of normal Q-Q plots and stem and leaf plots revealed no extreme values for any variable.

Data were evaluated to ensure that they met the core assumptions of the primary analysis used, repeated measures analysis of covariance (RM-ANCOVA). The assumption of homogeneity of variance was satisfied for positive and negative emotion when assessed using Levene's Test of Equality of Error Variances ($p > .05$). The assumption of homogeneity of regression slopes was also met, given that emotion regulation group assignment did not interact with any covariates (gender, BMI, and baseline measurements of positive emotion (PE), negative emotion (NE), and momentary rumination) used in this analysis. However, the assumption of homogeneity of covariance

was not satisfied, as assessed via Box's test of equality of covariance (F(20, 47232.49)=2.13, $p < .01$). This demonstrates that covariance matricies for positive emotion scores are not equal across groups. Given that repeated measures tests are robust to violations of homogeneity of covariance, no transformations were performed.

The Shapiro-Wilks Test for Normality revealed that positive emotion scores at T1 were normally distributed and emotion scores at all other time points were non-normally distributed ($p<.05$). A visual examination of the distributions revealed leptokurtosis, which was present for negative emotion at T1 (kurtosis = 4.69, SE = 0.44), at T2 (kurtosis = 2.58, SE = 0.44), and at T3 (kurtosis =5.06, SE=.440). Given that this study recruited a nonclinical sample, it is unsurprising that the majority of the sample reported low levels of negative emotion. Considering that repeated measures tests are robust to violations of normality, and that all distributions were within acceptable ranges of skewness (+/- 2.5), no transformations of emotion scores were necessary. Following data collection, cleaning, and checking for assumptions, descriptive statistics and zero-order correlations were computed and examined. Descriptive statistics are outlined in detail in Table 1.

Primary Analyses

This study used a 3 group by 2-block design to investigate differences between the 3 levels of the categorical IV (comfort eating, squeeze ball, or no task) on 2 continuous primary outcome variables: negative and positive emotion. In our fourth hypothesis, we also examined the continuous variable of state rumination. We ran analyses first without covariates to determine primary findings. Then, to control for any systematic effects of baseline hunger level, gender, and BMI on comfort eating, we added these time-invariant

covariates to the model and determined if significant effects were maintained beyond these covariates. These results are reported below for each specific aim.

Aim 1

Our first aim involved validating the efficacy of the modified Trier Social Stress Test for inducing emotional stress. To do this, we used a repeated-measures multivariate analysis of covariance (RM-MANCOVA) to compare reports of negative and positive emotion collected from participants at baseline to scores collected immediately after completion of the TSST (PANAS-1 relative to PANAS-2). In this analysis, we controlled for the effect of gender on reports of emotion.

Findings indicated support for Hypothesis One. As expected, negative emotion increased significantly from PANAS-1 (M=12.23, SD=3.18) to PANAS-2 (M=16.52, SD=6.05), ($F(1, 117)=69.90$, $p < .01$, $\eta_p^2 = 0.37$) and positive emotion decreased significantly from PANAS-1 (M=28.38, SD=6.72) to PANAS-2 (M=23.11, SD=8.31), ($F(1, 117)=4.50$, $p < .04$, $\eta_p^2 = 0.04$). These significant increases in negative emotion and reductions in positive emotion indicate the ability of the TSST to elicit emotional distress in this experiment. There was also a significant interaction between the covariate, gender, and negative emotion ($F(1, 117)=13.46$, $p < .01$, $\eta_p^2 = 0.10$), indicating that the effect of the stressor on negative emotion differed by gender. Women endorsed a larger increase in negative emotion after the stressor than did men. There was no significant interaction between gender and positive emotion, though the effect was trending towards significance (p=.08) and should be explored using a larger sample.

Aim 2

The second aim of this study was to test the "comforting" effects of consuming sweet nutrient-dense food after stress. First, we wanted to ensure that the effect of the stress induction did not differ across emotion regulation groups (e.g., M&Ms, squeeze ball, no task). As expected, there were no significant group differences ($p>.05$). Next, we used an RM-MANCOVA to examine the main effect of group assignment on changes in negative and positive emotion from Time 2 (collected after completion of the TSST) to Time 3 (collected immediately after completing the 5-minute emotion regulation task).

Controlling for baseline levels of emotion, subjects in all groups reported significantly more negative emotion immediately after the TSST (M=16.52, SD=6.05) than after the emotion regulation manipulation (M=13.03, SD=3.96), ($F(1, 114)=5.67$, $p<.02$, $\eta_p^2= 0.047$). This effect demonstrates that participating in a 5-minute emotion regulation task, on average, resulted in small declines in negative emotion. Following stress, individuals who ate comfort food reported less negative emotion (a 2.43 point decrease on the PANAS) between Time 2 (M=15.38, SD=5.39) and Time 3 (M=12.95, SD=4.28). This demonstrated that comfort eating does reduce negative emotion. However, there was no significant effect of emotion regulation group on negative emotion, and no within-subjects interaction between group assignment and negative emotion ($p >.05$). These data suggest that neither the overall levels of negative emotion nor the amount that negative emotion decreased differed between groups. In essence, comfort eating was no more effective at reducing negative emotion than receiving nothing. Individuals who sat quietly following stress also experienced reductions in negative emotion (a 3.55 point decrease on the PANAS) between Time 2 (M=16.79,

SD=5.63) and Time 3 (M=13.24, SD=4.23). Further, observed power for detecting changes in emotion across emotion regulation groups in this study was moderate, though lower than desired (p=.63) (G*Power Version 3.1). Mean values of negative emotion over time are presented for all groups in Table 2, and are graphed out in Figure 3A.

Additionally, when adding covariates to the model, there were no significant between-group or within-group effects of BMI status or hunger on reports of change in negative emotion. And though there were no between-group effects of gender on negative emotion, there was a significant interaction between gender and negative emotion, such that women reported a greater decline in negative emotion (4.11 points) from Time 2 (M=17.64, SD=6.50) to Time 3 (M=13.53, SD=4.28) than did men (2.71 points) from Time 2 (M=15.13, SD=5.15) to Time 3 (M=12.42, SD=3.46), ($F(1, 113)=10.90$, $p<.01$, $\eta_p^2 = 0.09$). This effect was also similar in women and men in all groups, as there was no negative emotion by group by gender interaction (p>.05). Given that women's negative emotion was also more sensitive to the effects of the stressor, it is perhaps not surprising that they were more sensitive to the effects of the emotion regulation manipulation and were more comforted by these tasks than men. This effect may also be explained by the fact that women had higher negative emotion to regulate than did men. It is also possible that the women in this sample were more sensitive to their negative emotions and/or willing and able to report the decrease. Mean values of negative emotion over time are presented by gender in Table 3, and are graphed out in Figure 3B.

Upon examining changes in positive emotion, contrary to our hypotheses, mean levels of positive emotion across all groups were significantly higher immediately after the TSST (M=23.11, SD=8.31) than after the emotion regulation manipulation (M=21.92,

SD=8.95), ($F(1, 114)=13.13$, $p < .01$, $\eta_p^2 = 0.103$). Positive emotion items on the PANAS include "interested," inspired," "attentive," "alert," and "strong." Nearing the end of a 2-hour experiment, it is perhaps not surprising that reports of being "interested," "strong," or excited" would decline.

However, in line with our hypotheses, there was a significant interaction between positive emotion and group assignment ($F(1, 114)=3.95$, $p=.02$, $\eta_p^2 = 0.065$). Following stress, individuals who ate comfort food reported steady levels of positive emotion between Time 2 (M=23.58, SD=8.92) and Time 3 (M=23.50, SD=9.83), whereas those who just sat quietly reported declines in positive emotion (a 1.71 point decrease on the PANAS) between Time 2 (M=22.40, SD=7.95) and Time 3 (M=20.69, SD=8.10). This demonstrates that comfort eating prevented reductions of positive emotion in this sample, and suggests that comfort eating may have a greater impact on the positive emotion system than the negative emotion system[1]. Mean values of positive emotion over time are presented for all groups in Table 2, and are graphed out in Figure 4A.

Additionally, when adding covariates to the model, there were no significant within-group effects of BMI status or hunger on reports of change in positive emotion. However, there was a significant interaction between gender and positive emotion, $F(1, 113)=4.79$, $p=.03$, $\eta_p^2 = 0.04$. Women in the sample reported a greater decline in positive emotion (2.04 points) from Time 2 (M=20.98, SD=6.01) to Time 3 (M=18.94, SD=6.38) than did men, who barely reported a decline (0.11 points) from Time 2 (M=25.75, SD=9.95) to Time 3 (M=25.64, SD=10.28). This suggests that the emotion regulation

[1] Given that gender also significantly impacted change in positive emotion over time, it is possible that the unique effect of comfort eating on positive emotion was also influenced by gender effects. For this reason, conclusions regarding the unique influence of comfort eating on positive emotion should be interpreted with caution.

tasks, overall, produced greater declines in women's positive emotion than in men's. Mean values of positive emotion by gender over time are presented in Table 3 and graphed out in Figure 4B.

Aim 3

The third aim of this study was to compare the emotional impact of consuming sweet nutrient-dense food (e.g., M&Ms) with the impact of completing the squeeze ball distraction task. To do this, we used results from our previous analysis, with a focus on comparing the comfort eating and squeeze ball groups. With respect to negative emotion, though individuals who ate comfort food reported less negative emotion (a 2.43 point decrease on the PANAS) between Time 2 (M=15.38, SD=5.39) and Time 3 (M=12.95, SD=4.28), those who squeezed a stress ball following stress also experienced reductions in negative emotion (a 4.57 point decrease on the PANAS) between Time 2 (M=17.46, SD=7.06) and Time 3 (M=12.89, SD=3.33). Though both emotion regulation strategies reduced negative emotion, there was no significant main effect of emotion regulation group assignment ($p > .05$), indicating that comfort eating was no more effective at reducing negative emotion than using a squeeze ball. Mean values of negative emotion over time are presented for all groups in Table 2, and are graphed out in Figure 3A.

Upon examining changes in positive emotion, there was a significant interaction between positive emotion and group assignment ($F(1, 114)=3.95$, $p=.02$, $\eta_p^2 = 0.065$). Individuals who ate comfort food following stress reported steady levels of positive emotion between Time 2 (M=23.58, SD=8.92) and Time 3 (M=23.50, SD=9.83), whereas positive emotion decreased slightly (a 1.79 point decrease on the PANAS) between Time 2 (M=23.41, SD=8.22) and Time 3 (M=21.62, SD=8.86) for those who used a squeeze

ball. This demonstrated that comfort eating, versus a squeeze ball, prevented reductions of positive emotion in this sample. These data suggest that the impact of comfort food on the positive emotion system deserves further exploration. Mean values of positive emotion over time are presented in Table 2 and graphed out in Figure 4A.

Further, the effect of the emotion regulation tasks differed by gender, as indicated by a significant gender by positive emotion interaction explored earlier in this paper. We examined the gender by group by positive emotion interaction, which was not sufficiently powered but was trending towards statistical significance ($p=0.10$). These results suggest that the emotion regulation tasks, and particularly the control condition, affected men and women's positive emotion differently. Women in the no task control group reported a 3.04 point decline in positive emotion on the PANAS, whereas men in this condition reported a small 0.36 point increase in positive emotion. While the control condition was the least positive for women, the squeeze ball condition was the least positive for men, who reported a 2.63 point reduction in positive emotion, as compared to women in this group's 1.39 point decline. The most positive condition for both genders was the comfort food condition, as men reported a modest 0.54 point increase and women reported a small 0.64 point decrease in positive emotion. Mean values of positive emotion by gender by condition over time are presented in Table 3, and are graphed out in Figure 4C.

Aim 4A

Broadly, our fourth aim examined the relationship between comfort eating and state rumination. First, we tested the hypothesis that eating sweet nutrient-dense food (e.g., M&Ms) after stress would significantly decrease state rumination, relative to individuals

in the no task and stress ball control groups. To do this, we used an RM-MANCOVA to examine the main effect of emotion regulation group assignment on changes in reports of state rumination from Time 2 (collected after completion of the TSST) to Time 3 (collected immediately after completing the 5-minute emotion regulation task).

We did the initial analysis without controlling for baseline momentary rumination, as rumination scores across groups at Time 1 were not significantly different ($p>.05$). Results showed that within subjects in all groups, momentary rumination was significantly higher immediately after the TSST (M=39.44, SD=18.19) than it was after the emotion regulation manipulation (M=37.18, SD=16.81), a statistically significant albeit small effect ($F(1, 116)=6.62$, $p < .01$, $\eta_p^2 = 0.05$). This indicated that individuals across groups reported significantly less engagement in rumination after a 5-minute task than immediately after a stressful task. This effect held when controlling for gender.

Further, there was no between-subjects effect of emotion regulation group assignment on momentary rumination ($p>.05$). Notably, though, the within-subjects relationship between momentary rumination and condition assignment was trending towards an interaction. Though the analysis was not statistically significant ($p=0.161$), likely due to insufficient power (.380), the trend indicates that reduction in momentary rumination may have been different across emotion regulation groups, justifying our decision to further explore the change between groups.

Following stress, individuals who ate comfort food reported less momentary rumination (a 0.97 point decrease on the MRA) between Time 2 (M=36.35, SD=18.36) and Time 3 (M=35.38, SD=16.40). This demonstrates that comfort eating does reduce momentary rumination, but the absence of a significant between-subjects or within-

subjects effect of condition on momentary rumination indicates that comfort eating was no more effective at reducing momentary rumination than using a stress ball or receiving nothing. Individuals who sat quietly following stress experienced reductions in momentary rumination (a 1.24 point decrease on the MRA) between Time 2 (M=41.43, SD=18.44) and Time 3 (M=40.19, SD=16.15). And, contrary to our hypotheses, the most significant declines in momentary rumination were experienced by those who used a stress ball (a 4.81 point decrease on the MRA) between Time 2 (M=40.51, SD=17.77) and Time 3 (M=35.70, SD=17.93). This suggests that using a stress ball may, in fact, be the most effective strategy for reducing rumination. Mean values are presented in Table 2 and are graphed out in Figure 5A.

Results also indicate significant effects of gender on momentary rumination in this experiment. When controlling for gender, there was a significant between-subjects effect of the variable on momentary rumination. Though the effect was small, women reported significantly more momentary rumination overall at Time 2 (M=41.76, SD=19.71) and Time 3 (M=40.67, SD=18.74) than did men at Time 2 (M=36.55, SD=15.80) and Time 3 (M=32.83, SD=12.94), ($F(1, 115)=4.35$, $p < .04$, $\eta_p^2 = 0.04$). This finding is consistent with the previous literature indicating higher levels of rumination in women versus men (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Mean values are presented in Table 3 and are graphed out in Figure 5B.

Aim 4B

The goal of our fourth and final aim was to test the effect of comfort eating on changes in negative and positive emotion as a function of momentary rumination level. More specifically, we hypothesized that greater reductions in momentary rumination

would predict larger reductions in negative emotion and elevations in positive emotion in the comfort eating group in particular. To do this, we first indexed change in momentary rumination scores (MRA-change) by calculating the difference between momentary rumination before and after completing the 5-minute emotion regulation task (MRA-3 – MRA-2). We then ran an RM-MANCOVA, examining the interaction between emotion regulation group assignment (M&Ms, stress relief ball, no task) and change in momentary rumination in predicting change in negative and positive emotion.

While controlling for the effects of gender and baseline negative and positive emotion, results indicated that contrary to hypotheses, the interaction between change in state rumination and group assignment in predicting change in positive and negative emotion was not significant, though it was trending towards significance (p=.160). This indicated that, in a sample of healthy individuals, degree of change in momentary rumination did not have an impact on emotion that differed significantly across groups. Breaking this effect down, there was no significant interaction between the degree of change in rumination and negative emotion (p>.05), which is surprising considering the strong link in the literature between rumination and negative affect. However, the interaction between degree of change in rumination and positive emotion was significant ($F(1, 112) = 6.02$, $p < .02$, $\eta_p^2 = .051$). Though the effect was small, this indicated that those who reported larger declines in state rumination reported more positive emotion.

To more fully probe this question, we also examined this hypothesis using an alternative measurement of rumination. It is possible that, if individuals were not experiencing significant rumination, than comfort eating may not be as effective at changing emotion in that group. So we conducted a mean split, isolating individuals who

reported high levels of rumination (n=50) immediately after the stressor versus those who reported low rumination levels (n=69). We then conducted an RM-MANCOVA with rumination level as a between-subjects variable.

Results indicated that rumination level following the stressor interacted significantly with negative emotion ($F(1, 109) = 9.321$, $p < .01$, $\eta_p^2 = .08$), suggesting that change in negative emotion from Time 2 to Time 3 was different depending on rumination level. Means indicated that individuals with low rumination reported a 1.87 point decline in negative emotion on the PANAS from Time 2 (M=13.96, SD=3.85) to Time 3 (M=12.09, SD=3.26), a much smaller drop than those who reported high rumination, who experienced a 5.72 point drop in negative emotion from Time 2 (M=20.06, SD=6.74) to Time 3 (M=14.34, SD=4.48). This demonstrates that the emotion regulation condition was more negatively reinforcing for high versus low ruminators. However, this effect was consistent across emotion regulation conditions, as the condition by rumination level by negative emotion interaction was not significant ($p>.05$). Mean values of negative emotion by post-stress state rumination level over time are presented in Table 5, and are graphed out in Figure 5D.

Rumination level also interacted significantly with positive emotion ($F(1, 109) = 14.815$, $p < .01$, $\eta_p^2 = .120$), suggesting that change in positive emotion from Time 2 to Time 3 was different depending on rumination level. Contrary to our hypotheses, means indicate that individuals with low rumination reported a small 0.93 point decrease in positive emotion on the PANAS from Time 2 (M=23.81, SD=8.91) to Time 3 (M=22.88, SD=9.40), in contrast to high ruminators, who experienced a larger 1.54 point drop in positive emotion from Time 2 (M=22.14, SD=7.39) to Time 3 (M=20.60, SD=8.20). This

demonstrates that individuals with high rumination levels were less positively reinforced by the emotion regulation conditions than low ruminators, an effect that was consistent across emotion regulation conditions, as the condition by rumination level by positive emotion interaction was not significant (p>.05). Changes in specific positive emotions reveal that high ruminators reported larger decreases in being "determined" ($F(1, 110) = 3.83$, $p < .05$, $\eta_p^2 = .034$) and "active" ($F(1, 110) = 5.48$, $p < .02$, $\eta_p^2 = .05$) after completing the emotion regulation condition than low state ruminators. Mean values of positive emotion by post-stress state rumination level over time are presented in Table 5, and are graphed out in Figure 5D.

Interestingly, our post-hoc examination of changes in specific positive emotions before and after completing the emotion regulation tasks revealed that reports of feeling "excited" changed differently across conditions ($F(2, 110) = 3.31$, $p < .04$, $\eta_p^2 = .06$), and differently across conditions and rumination levels together ($F(2, 110) = 3.59$, $p < .03$, $\eta_p^2 = .06$). Results revealed that comfort eaters experienced a smaller decrease in feeling "excited" than those who sat quietly or used a stress ball. Examining this effect across rumination levels, all individuals in all groups reported significant decreases in feeling "excited," except for high ruminators in the comfort eating group, who reported a significant *increase* in excitement. This suggests that, though high ruminators who comfort eat experience decreases in feelings of activity and determination, they experience increases in excitement that may be particularly reinforcing.

IV. Discussion

Comfort eating, or consuming highly palatable food in an effort to reduce negative emotion, has long been conceptualized as an emotion regulation strategy in the literature (Epel et al., 2001; Gibson, 2012; Stone & Brownell, 1994) and in lay understanding (Gibson, 2012). However, comfort eating's ability to provide relief from negative emotion is unclear, with some studies demonstrating that comfort eating reduces negative emotion (Macht & Mueller, 2007; Macht, 2008) and more recent work showing that comfort eating was no better at reducing negative emotion than merely receiving food or doing nothing (Wagner et al, 2014). Given this contradictory evidence, the current study aimed to bring more clarity to our understanding of the emotional functions of comfort eating. This study also fills important gaps in the current literature by investigating the potential role of previously unexplored variables, positive emotion and rumination, in reinforcing comfort eating. This work also builds on methodological limitations in prior research by using a standardized comfort food, a control group, and a non-food comparison group to provide a more rigorous and comprehensive test of comfort eating.

To fulfill these aims, we examined reports of emotion and rumination in healthy adults, who underwent a stressful task and then engaged in 1 of 3 emotion regulation tasks: eating comfort food (M&Ms), using a stress relief ball, or sitting quietly. A repeated-measures MANCOVA revealed that, while comfort eating significantly reduced negative emotion as expected, it was no more effective than doing nothing or using an alternative emotion regulation strategy. Eating comfort food, sitting quietly and using a stress ball comparably reduced negative emotion. Findings examining positive emotion were more compelling, suggesting that comfort eating may have a unique impact on the positive emotion system. While both participants who used a stress ball and those who sat

quietly experienced significant declines in positive emotion, comfort eaters displayed steady levels of positive emotion. Our findings also shed light on the role of rumination in comfort eating, revealing that comfort eating reduced state rumination. However, contrary to expectations, so did sitting quietly and using a stress ball, with the stress ball producing in the largest declines in state rumination. Finally, the emotion regulation tasks were both more negatively reinforcing and less positively reinforcing for high versus low state ruminators. High state ruminators across conditions experienced greater declines in negative and positive emotion than low state ruminators after the emotion regulation tasks. The implications of these findings are discussed below.

Does comfort eating provide relief from negative emotion?

Results from the current study demonstrated that comfort eating provided significant relief from negative emotion, a finding that supports the notion that comfort eating is an effective method for regulating negative emotion. However, this must be interpreted with caution, as sitting quietly also elicited reductions in negative emotion, making it difficult to say whether the food itself or the effects of time were responsible for the negative reinforcement. In fact, it is possible that those who experience relief after comfort eating, attributing this effect to the food, may develop a pattern of eating when stressed and prevent themselves from learning that time has comparable effects. These findings align with those of Wagner and colleagues (2014), supporting the notion that comfort eating may not be so comforting after all.

Alternatively, it is also possible that comfort eating, though initially reinforced by immediate relief from negative emotion, may be more robustly reinforced long-term

effects. As Dallman (2003) proposes in her model of comfort eating, eating when stressed may down-regulate the body's stress response over time, resulting in reduced sensitivity to stress and reinforcing comfort eating behavior (Adam & Epel, 2007; Dallman et al., 2003). To test this hypothesis, future studies should gather longer-term measurements of stress (e.g., cortisol measurements).

Further, this study was the first to test the effects of comfort eating against an active emotion regulation condition, with results indicating that comfort eating and using a stress relief ball produced comparable reductions in negative emotion. Comfort eating was no more effective at reducing negative emotion than using a squeeze ball, and actually, trends indicated that the squeeze ball produced larger declines in negative emotion. This is the first study to demonstrate empirically that stress relief balls are effective tools for reducing negative emotion, though these findings must be interpreted with the knowledge that sitting quietly also had similar effects. Collectively, these findings suggest that individuals who engage in comfort eating may experience similar benefits and fewer long-term consequences from choosing a more innocuous method of regulating, such as sitting quietly or using a stress relief ball.

The role of negative emotion in comfort eating must also be considered in the context of gender. Compared to men, women in this sample reported more negative emotion after the stressor and larger reductions in negative emotion after the emotion regulation tasks. This was true across groups, meaning that women who engage in comfort eating may experience more relief from negative emotion than men who comfort eat. Given this, it is unsurprising that rates of comfort eating are higher among women than men (Gibson, 2012; Wansink et al., 2003). Further, this effect also held when

controlling for M&M palatability, a test we performed given that women's preferred comfort foods are high-convenience snack foods versus men's preferred hot meals.

What drives comfort eating? The unique role of positive emotion

The relationship between comfort eating and positive emotion has been less explored in the literature. The current study demonstrated that overall positive emotion decreased after completing the emotion regulation tasks, but as expected, this effect was not present among comfort eaters, who reported steady levels of positive emotion. This suggests that comfort eating has a greater impact on the positive emotion system than sitting quietly or using a stress relief ball, a promising finding.

However, contrary to our hypotheses, overall positive emotion decreased and comfort eaters reported steady versus increased in positive emotion. Given that participants were nearing the end of a 2-hour experiment and were rating positive emotion items such as "interested," "inspired," and "strong," it is perhaps less surprising that overall positive emotion decreased. Though comfort eaters did not report increased positive emotion as expected, consuming M&Ms prevented declines in positive emotion in conditions that were otherwise positive emotion-reducing, meaning that comfort food boosted positive emotion. In particular, only comfort eaters reported sustained levels of excitement. Given this, in real-life situations that promote stress, like studying for a test or preparing for an interview, comfort eating may be used to boost feelings of excitement, happiness and alertness in situations where these emotions would otherwise decline.

Together, these findings suggest that comfort eating may be more reinforced by heightening positive emotion than by relieving negative emotion. This finding has implications for the treatment of comfort eating behavior, suggesting that efforts to

reduce comfort eating should include the use of more non-food rewards. Future research should replicate this finding in larger samples and in naturalistic studies. Additionally, given that Wagner and colleagues (2014) found that merely receiving food prevented reductions in negative emotion, it is possible that the anticipation of a food reward and not the consumption itself produces changes in positive emotion. To more fully examine this issue, future studies should test the impact of food, anticipated food, and anticipated non-food rewards on changes in positive emotion.

Finally, compelling gender differences emerged in reports of positive emotion changes, with women reporting greater declines in positive emotion after the emotion regulation tasks than men, who reported steady positive emotion. Among both genders, comfort eating was the most positive condition, with men reporting a small increase and women reporting a small decrease in positive emotion. This suggests that comfort eating, though it was the most positively reinforcing of the tasks for both genders, was more positively reinforcing for men than for women. Given the more robust effects of comfort food on positive emotion in men, it is unsurprising that men tend to comfort eat to maintain or enhance positive emotion (Dube, LeBel & Lu, 2005). In contrast, women tend to comfort eat in response to high negative emotion, which also makes sense given that comfort eating has more potent negative reinforcement effects for women.

Exploring the cognitive functions of comfort eating: the role of rumination

Little empirical research has investigated the relationship between comfort eating and the cognitive process of rumination. The current study aimed to fill this gap, and in line with our hypotheses, results demonstrated that comfort eating, sitting quietly and

using a stress relief ball significantly and comparably reduced state rumination. These results suggest that comfort eating is no more effective at reducing rumination than sitting quietly, a surprising result given that sitting quietly provides no distractions from thinking, whereas food consumption confers visual, oral and olfactory opportunities for distraction. One potential explanation for this may be that the rumination produced by a 15-minute laboratory-based stress task was relatively repairable, as opposed to rumination that may occur in the context of ongoing, real-life stressors. It is possible that sitting quietly and comfort eating have similar effects when stress is minor, but comfort eating may be more preferable and powerful in the context of moderate and less easily repairable stressors. An alternative explanation may be that, while comfort food provides a distraction, eating high-calorie food following stress may elicit feelings of guilt and a new topic to ruminate about. However, analyses of changes in guilt in this experiment do not support that hypothesis.

Further, though no task was significantly better at reducing state rumination, trends indicated that contrary to hypotheses, using a stress relief ball may provide more potent relief from rumination than comfort eating or sitting quietly. While this finding should be replicated in a study designed for this purpose, ours is the first study to show that a stress relief ball effectively reduces rumination. Clinically, this knowledge suggests that using a stress relief ball may help individuals with high levels of rumination reduce perseverative thinking.

We also explored the relationship between change in rumination and concomitant changes in emotion, hypothesizing that greater reductions in momentary rumination would predict larger reductions in negative emotion and elevations in positive emotion in

the comfort eating group in particular. However, we found no significant group differences, which is not surprising in light of our previous finding that rumination changed comparably across groups. Outside of group differences, we found that greater changes in rumination were unrelated to changes in negative emotion, a surprising result considering the exhaustive literature that links negative affect and rumination (Nolen-Hoeksema, 2000; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008; Selby, Anestis & Joiner, 2008). One possible explanation for this result is our method of analysis; reporting a sizeable decline in rumination may capture and conflate two groups: individuals who did not engage in significant rumination in the first place, whose rumination was repairable and readily decreased, versus individuals engaging in high levels of rumination who were particularly relieved by the tasks. The former group likely had less negative emotion to regulate in the first place, potentially masking the declines in negative emotion experienced by those with more significant rumination.

To enhance the precision of our analysis and capture the impact of state rumination level on emotion, we performed this analysis alternatively by identifying individuals who experienced high versus low state rumination after the stressor, and measuring the impact of rumination level on concomitant changes in emotion. Results indicated that after the emotion regulation tasks, negative emotion in high ruminators declined by triple the amount as low ruminators, indicating that the emotion regulation tasks were significantly more negatively reinforcing for high versus low ruminators.

This finding was true across conditions, and may have important implications for our understanding of the reinforcement functions of comfort eating. Though comfort eating was not more negatively reinforcing than sitting quietly overall, when an

individual experienced high levels of state rumination, comfort food provided significant relief from negative emotion, enhancing the negative reinforcement value of comfort food. This suggests that, though comfort eating is not more powerful than other strategies at regulating emotion, individuals and particularly high ruminators experience some comforting effects of eating and may use it as a go-to method of coping. However, habitually using this strategy may prevent comfort eaters from learning alternative methods of regulating, and our findings suggest that teaching alternative skills like using a stress relief ball would be valuable. Collectively, these findings suggest that future research should consider the role of rumination when exploring the negative reinforcement functions of comfort eating

With regards to positive emotion, contrary to expectations we found that high state ruminators also experienced larger declines in positive emotion when compared to low state ruminators. This effect that was consistent across emotion regulation conditions, suggesting that comfort eating is less positively reinforcing for people experiencing high levels of rumination. To further understand these findings, we performed a post-hoc analysis of changes in specific positive emotions, which revealed that, in particular, high state ruminators reported larger decreases in feeling "determined" and "active" than low state ruminators. This suggests that, for individuals who are engrossed in self-focused, critical perseveration about problems and consequences, feelings of engagement with the world and determination inevitably decrease, even given comfort food, quiet sitting or a stress ball. However, it is notable that high ruminating comfort eaters alone reported significantly heightened excitement following food consumption, suggesting that while some positive emotions decreased, the effect was not

so simple. When individuals experience high levels of aversive rumination, comfort eating may be particularly exciting, a factor that may motivate and reinforce the behavior.

With regard to gender, women in this sample displayed consistently higher levels of rumination than men, a result that is consistent with a large body of research on gender differences in rumination (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Further, all emotion regulation tasks produced larger decreases in rumination for men versus women, as women's rumination was more robust to change than men's. These results suggest that comfort eating may serve different primary functions between genders; for women more prone to high rumination, comfort eating may provide strong negative reinforcement by reducing rumination. For men less prone to rumination and more likely to comfort eat to maintain positive emotion, comfort eating may be reinforcing by increasing and maintaining positive emotions. These findings should be further explored in larger samples and in naturalistic settings.

Clinical Implications

Our findings have important implications for understanding the emotional functions of comfort eating. This is one of the first studies to demonstrate that comfort eating, in contrast to other emotion regulation strategies, has a unique and significant impact on the positive emotion system after stress. This may have implications for the treatment of comfort eating behavior, suggesting that providing non-food rewards that increase positive emotion may help individuals replace maladaptive comfort eating patterns with more adaptive regulation strategies. This recommendation aligns with strategies that are taught in evidence-based psychotherapies. For example, increasing

adaptive self-rewards and pleasant events in Behavioral Activation for Depression (BA; Jacobson, Martell & Dimidjian, 2001), teaching adaptive coping strategies in Cognitive Behavioral Therapy (CBT; Hollon & Beck, 1994), and learning emotion regulation skills in Dialectical Behavior Therapy (DBT; Linehan, 1993). Further, all of these treatments have been successful in treating binge-eating, including CBT (Wilfley & Cohen, 1997), DBT (Telch, Agras & Linehan, 2001), and even BA in obese individuals with co-morbid depression (Pagoto, Bodenlos, Schneider, Olendzki, Spates & Ma, 2008). Together, our findings and current clinical research suggest that using adaptive coping strategies to assist in the treatment of comfort eating is an important area for future research.

The current study also reveals a significant role of rumination in comfort eating behavior. While we did not find that comfort eating was more effective than other strategies for reducing rumination, comfort eating was more negatively reinforcing for high versus low ruminators in this study. This finding suggests that comfort food may be particularly appealing for individuals who often experience elevated rumination, as comfort eating provides potent negative reinforcement for them while also helping maintain levels of positive emotion, particularly excitement, in times of stress. Clinically, this information suggests that interventions aimed at reducing stress-induced rumination may reduce the negatively reinforcing properties, and thus the persistence, of comfort eating behavior. For example, mindfulness strategies may heighten awareness of rumination and facilitate its reduction. Unsurprisingly then, mindfulness is a core component of DBT for binge-eating (Telch, Agras & Linehan, 2001) and mindfulness-based eating awareness (Kristeller & Wolever, 2010). Further, our findings suggest that pairing these approaches --rumination reduction strategies (e.g., mindfulness techniques

or stress relief ball) with exciting non-food rewards (e.g. those incorporated into BA, CBT, and DBT)-- may be a particularly effective strategy for replacing comfort eating with more adaptive strategies for regulating and is a topic for future research.

Limitations and future directions

This work must be interpreted in light of several limitations. First, this study used self-report measures of state emotion and rumination. These measures rely on participants' insight into their own emotional and cognitive state, which may not be accurate and may differ across individuals, and future research should certainly replicate this work using biological measures of emotion and rumination. Despite this limitation, the self-report measures used in this study were largely state measures, limiting problems with retrospective recall that many self-report measures involve, and measures of emotion used in this study have been well-validated across studies (PANAS; Watson, Tellegen & Clark, 1988). Our assessment of momentary rumination, however, has not yet been validated and findings with regard to rumination should be interpreted with caution. Finally, emotion and rumination were measured 5 times throughout this study, and the repetition of these surveys multiple times during the study may result in demand effects that decrease participants' cognitive resources and attention to the measure after repeated presentations, or reactivity effects that may occur when reporting emotions may in and of itself prompt changes. These potential effects may limit the accuracy of these measures. However, these effects may be reduced by short survey length, and this measurement method is also consistent with previous research done on comfort eating (Epel et al., 2001; Wagner et al., 2014). Further, our manipulation checks revealed that, when asked if they experienced any stress during the experiment, only 7 of 119 participants reported

"no," suggesting that the majority of participants were moderately engaged with the experiment to the point that it caused them stress.

Additionally, this study was conducted experimentally in a lab setting using a standardized stress induction, and results may not generalize to people's experiences of stress and comfort eating in naturalistic settings. To reduce this concern, this study used a well-validated stress induction that included cognitive challenges (e.g., serial subtraction), ego-threatening tasks (e.g., speech about personal weaknesses), and a social evaluative component that make the stressor personally relevant (Kirschbaum, Pirke & Hellhammer, 1993; Zorawski, Blanding, Kuhn, & LaBar, 2006). In this respect, this study improves upon prior comfort eating research, which uses sad film clips that are not personally salient to participants (Macht & Mueller, 2007; Wagner et al., 2014).

This study was also conducted in a nonclinical sample, who tended to report overall low levels of negative emotion. Though the aim of this study was to examine the emotional functions of comfort eating in a healthy sample, the low variance in negative emotion, coupled with our moderate but not robust observed power (.630), may limit our ability to detect small differences between groups in the emotional functions of comfort eating versus other emotion regulation strategies. For this reason, this study should be conducted with a larger and more clinically diverse sample to provide a more robust examination of the emotional functions of this behavior.

Conclusions

Methodological strengths of this study included use of a standardized comfort food, a well-validated and generalizable stress induction task, and inclusion of both an inactive control group and an active emotion regulation comparison group. From a theoretical

perspective, strengths of this study included providing a comprehensive examination of the emotional functions of comfort eating, with a novel focus on positive emotion, and the consideration of cognitive variables like rumination.

Collectively, findings from this study suggest that comfort eating may be complexly reinforced through multiple pathways. Most notably, our results suggest that comfort eating has a unique impact on the positive emotion system, promoting the maintenance and elevation of positive emotion in stressful situations. Thus, positive reinforcement may be an important and unique function of comfort eating, a finding that should be explored in naturalistic research. Additionally, though our findings suggest that comfort food is not more comforting than other strategies for regulating, we did find that comfort eating provides more powerful negative reinforcement for those with elevated versus low state rumination. For individuals who experience high levels of rumination, an occurrence more common among women and in those who experience chronic stress, comfort food may provide significant relief from negative emotion, reinforcing the behavior and preventing individuals from learning that sitting quietly may have a similar effect (Gerin et al., 2012; Johnson et al., 2014). These results suggest that relief from rumination may be an important function of comfort eating behavior, and should be the topic of future research.

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Table 1
Baseline participant demographics by study condition (N=119)

	Comfort Food (n=40)	**Squeeze Ball (n =36)**	**No Task Control (n=42)**
	M (SD)	**M (SD)**	**M (SD)**
Age	20.45 (2.74)	20.42 (1.96)	19.98 (2.33)
BMI	23.28 (3.40)	22.49 (3.46)	23.77 (3.88)
Hunger	17.45 (3.72)	18.19 (3.41)	17.05 (3.45)
	n (%)	**n (%)**	**n (%)**
Race/Ethnicity:			
Non-Hispanic, White	36	29	35
Hispanic	4	8	7
Other	0	0	0
Gender:			
Female	21	20	24
Male	19	16	18
Marital Status:			
Married/In a committed relationship	13	10	11
Single/Dating	27	27	31
Separated/Divorced/Widowed	0	0	0
Unknown	0	0	0
Family SES Background:			
Low Income	7	8	3
Moderate Income	30	25	35
High Income	3	4	4

Table 2
Change in emotion and rumination by emotion regulation group over time

	Comfort Food (n=40)		**Squeeze Ball (n =36)**		**No Task Control (n=42)**	
	M	*SD*	M	*SD*	M	*SD*
Negative Emotion (NE)						
Baseline (T1)	11.83	*3.07*	12.27	*2.83*	12.57	*3.59*
Post-Stress (T2)	15.38	*5.39*	17.46	*7.06*	16.79	*5.63*
Post-Manipulation (T3)	12.95	*4.28*	12.89	*3.33*	13.24	*4.23*
Positive Emotion (PE)						
Baseline	28.48	*6.89*	28.76	*7.10*	27.95	*6.34*
Post-Stress	23.58	*8.92*	23.41	*8.22*	22.40	*7.95*
Post-Manipulation	23.50	*9.83*	21.62	*8.86*	20.69	*8.10*
State Rumination						
Baseline	36.53	*13.83*	38.30	*12.18*	37.05	*10.99*
Post-Stress	36.35	*18.36*	40.51	*17.77*	41.43	*18.44*
Post-Manipulation	35.38	*16.40*	35.70	*17.93*	40.19	*16.15*

Table 3
Change in emotion and rumination by gender over time

	Women (n=66)		**Men (n =53)**	
	M	*SD*	M	*SD*
Negative Emotion (NE)				
Baseline (T1)	11.88	*2.97*	12.66	*3.01*
Post-Stress (T2)	17.64	*6.50*	15.13	*5.15*
Post-Manipulation (T3)	13.53	*4.28*	12.42	*3.46*
Positive Emotion (PE)				
Baseline	26.59	*5.39*	30.60	*7.56*
Post-Stress	20.98	*6.01*	25.75	*9.95*
Post-Manipulation	18.94	*6.38*	25.64	*10.28*
State Rumination				
Baseline	38.70	*12.75*	35.47	*11.55*
Post-Stress	41.76	*19.71*	36.55	*15.80*
Post-Manipulation	40.67	*18.74*	32.83	*12.94*

Table 4
Change in positive emotion and rumination by gender and emotion regulation group over time

	Women (n=66)			**Men (n =53)**		
	M&Ms (n=21)	Squeeze Ball (n=21)	No Task (n=24)	M&Ms (n=19)	Squeeze Ball (n=16)	No Task (n=18)
	M *(SD)*			M *(SD)*		
Negative Emotion (NE)						
Baseline	11.62 *(2.71)*	12.10 *(3.06)*	11.92 *(3.22)*	12.05 *(3.49)*	12.50 *(2.58)*	13.44 *(3.96)*
Post-Stress	17.00 *(5.27)*	18.81 *(8.65)*	17.17 *(5.34)*	13.58 *(5.06)*	15.69 *(3.74)*	16.28 *(6.11)*
Post-Manipulation	14.04 *(5.03)*	13.43 *(3.80)*	13.17 *(4.10)*	11.74 *(2.94)*	12.19 *(2.54)*	13.33 *(4.51)*
Positive Emotion (PE)						
Baseline	26.81 *(4.81)*	25.48 *(4.69)*	27.38 *(6.39)*	30.32 *(8.39)*	33.06 *(7.54)*	28.72 *(6.38)*
Post-Stress	21.63 *(5.73)*	22.16 *(5.27)*	23.13 *(6.78)*	25.57 *(10.56)*	24.40 *(9.30)*	22.17 *(9.49)*
Post-Manipulation	20.99 *(6.52)*	20.77 *(6.61)*	20.09 *(6.24)*	26.11 *(11.15)*	21.77 *(9.48)*	22.53 *(9.88)*
State Rumination						
Baseline	37.81 *(13.63)*	40.76 *(13.94)*	37.67 *(11.11)*	35.11 *(14.28)*	35.06 *(8.80)*	36.22*(11.09)*
Post-Stress	39.95 *(19.32)*	44.57 *(20.67)*	40.88 *(19.78)*	32.37 *(16.85)*	35.19 *(11.61)*	42.17*(17.01)*
Post-Manipulation	39.57 *(16.55)*	40.76 *(21.91)*	41.54 *(18.31)*	30.74 *(15.35)*	29.06 *(6.96)*	38.39*(13.02)*

Table 5
Change in negative and positive emotion by state rumination level over time

	Low State Rumination After Stress (n=69)		**High State Rumination After Stress (n =50)**	
	M	*SD*	M	*SD*
Negative Emotion (NE)				
Baseline (T1)	11.55	*2.28*	13.16	*3.96*
Post-Stress (T2)	13.96	*3.85*	20.06	*6.74*
Post-Manipulation (T3)	12.09	*3.26*	14.34	*4.48*
Positive Emotion (PE)				
Baseline	28.45	*7.35*	28.28	*5.82*
Post-Stress	23.81	*8.91*	22.14	*7.39*
Post-Manipulation	22.88	*9.40*	20.60	*8.20*

Figure 1
Procedure flow visualization

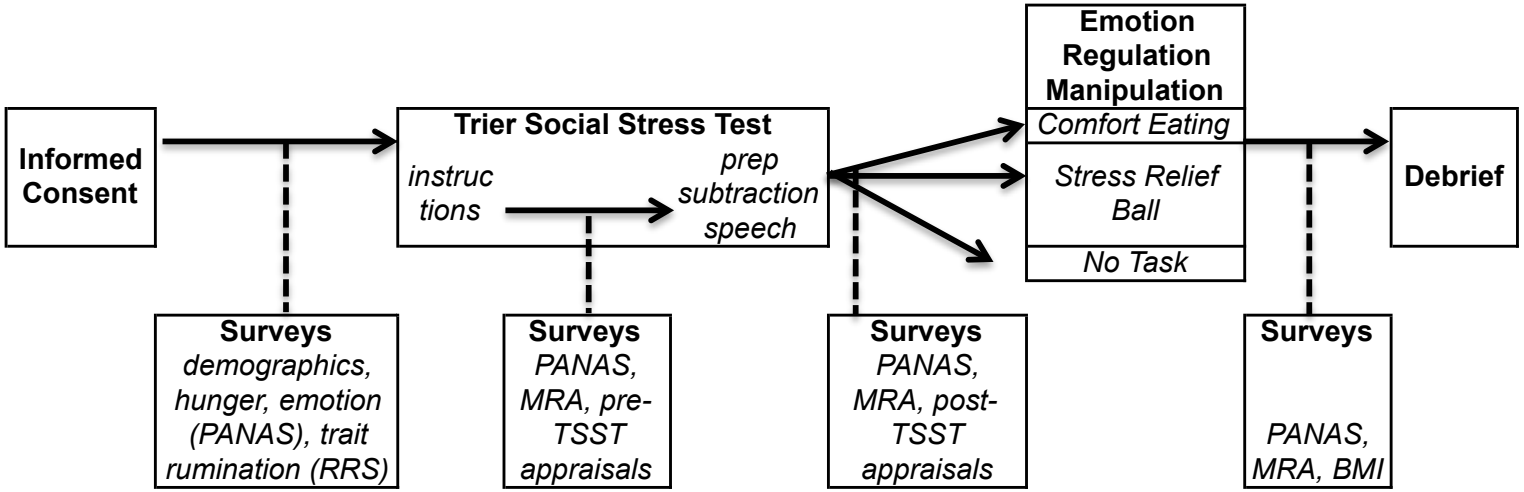


Figure 2
Consort diagram

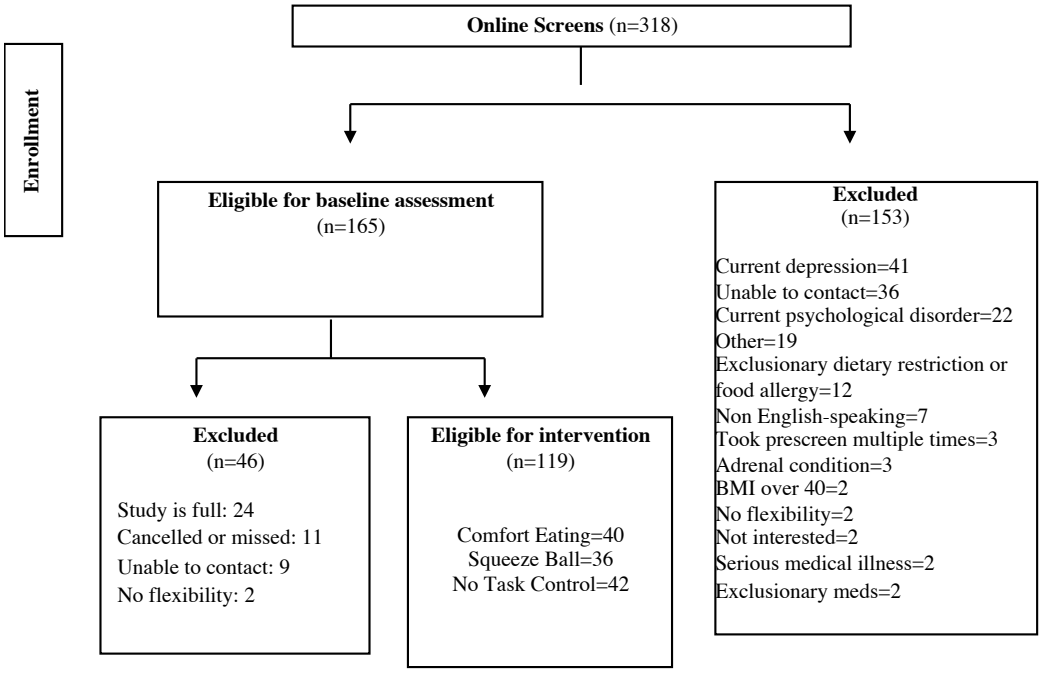


Figure 3A

Effect of Emotion Regulation Group on Change in Negative Emotion Over Time

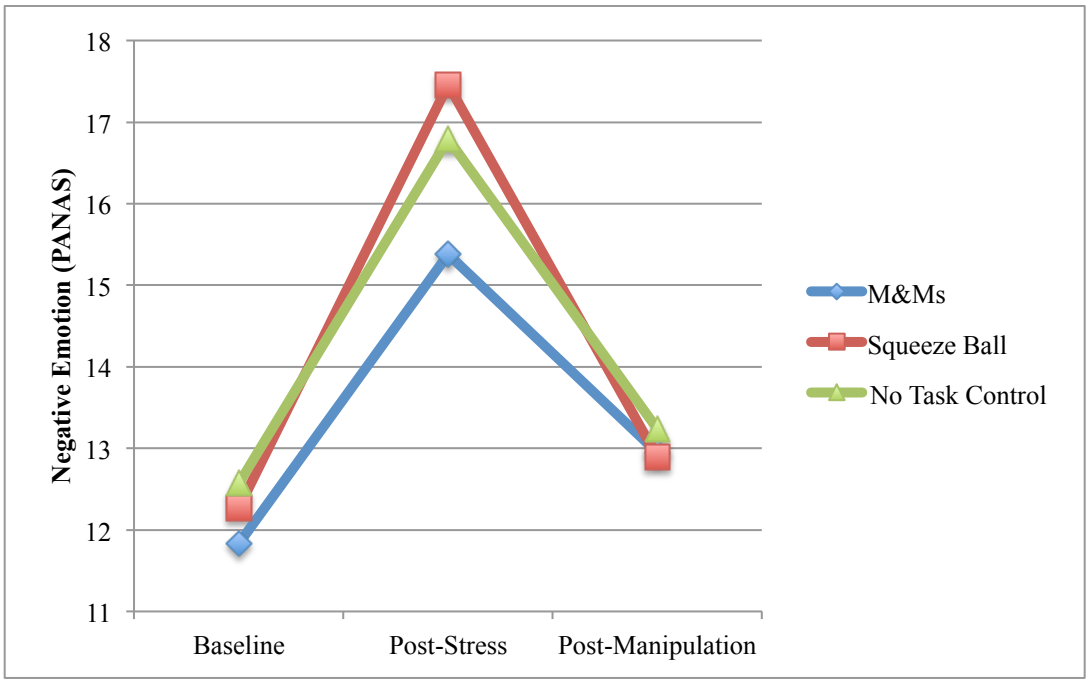


Figure 3B

Effect of Gender on Change in Negative Emotion Over Time

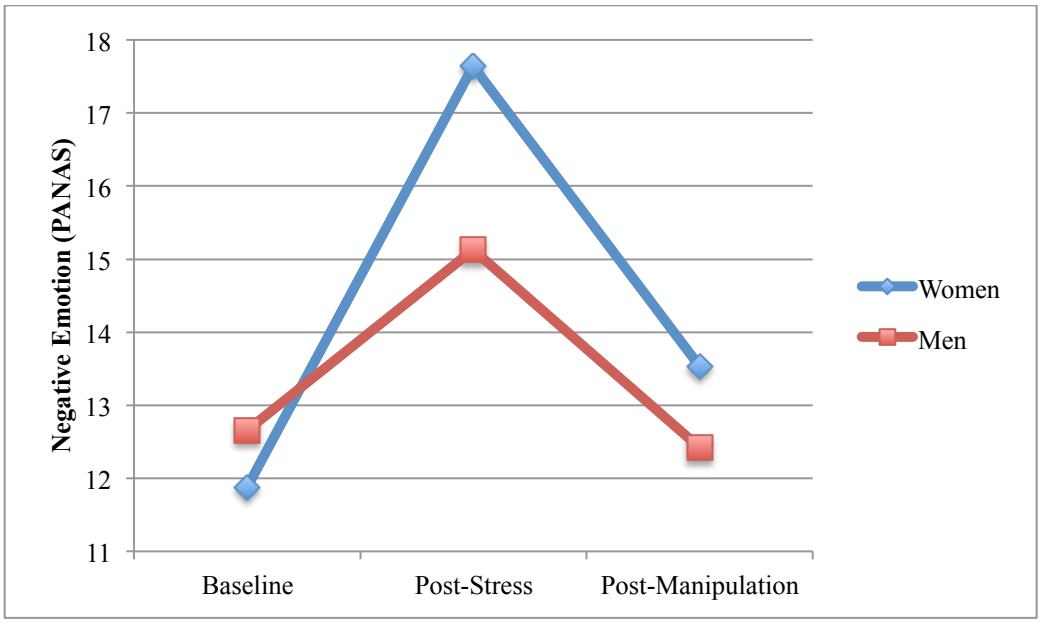


Figure 3C

Effect of Gender and Emotion Regulation Group on Change in Negative Emotion Over Time

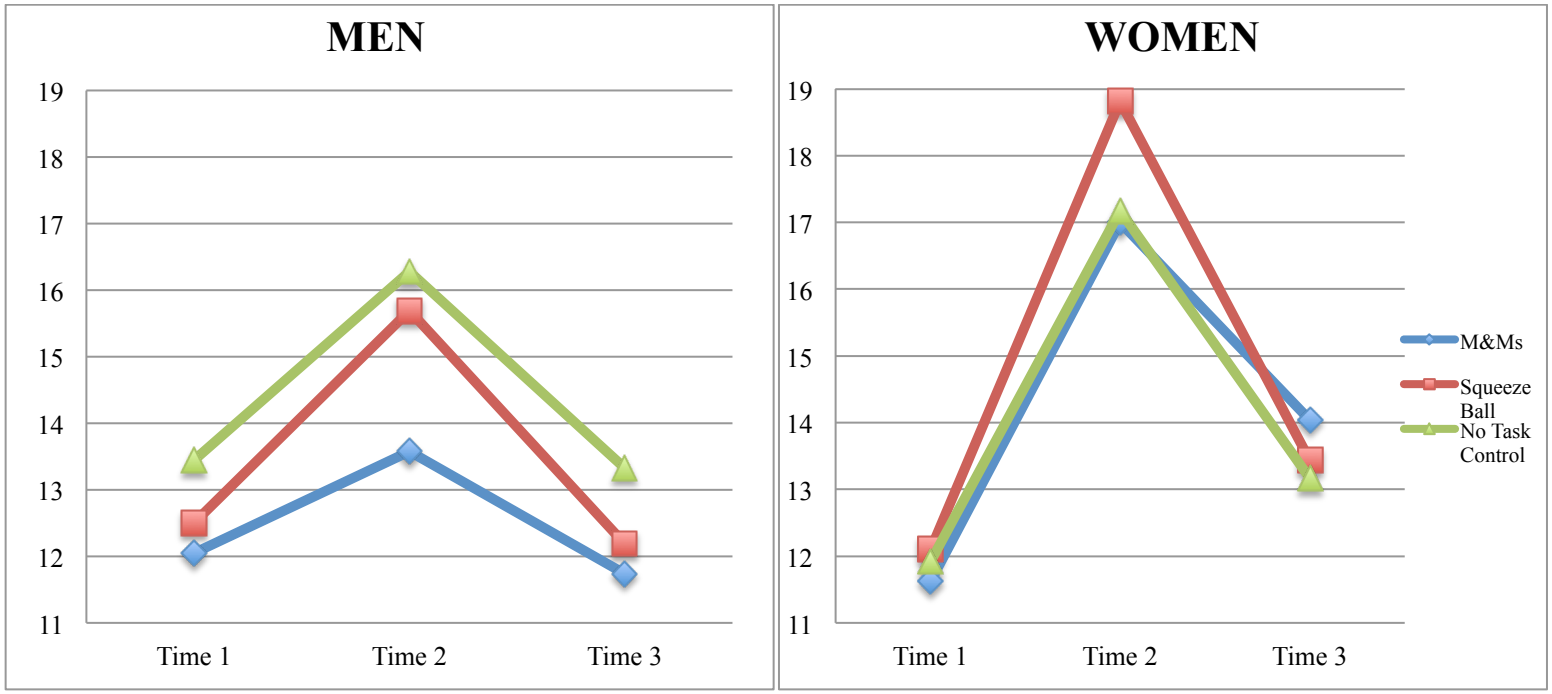


Figure 4A
Effect of Emotion Regulation Group on Change in Positive Emotion Over Time

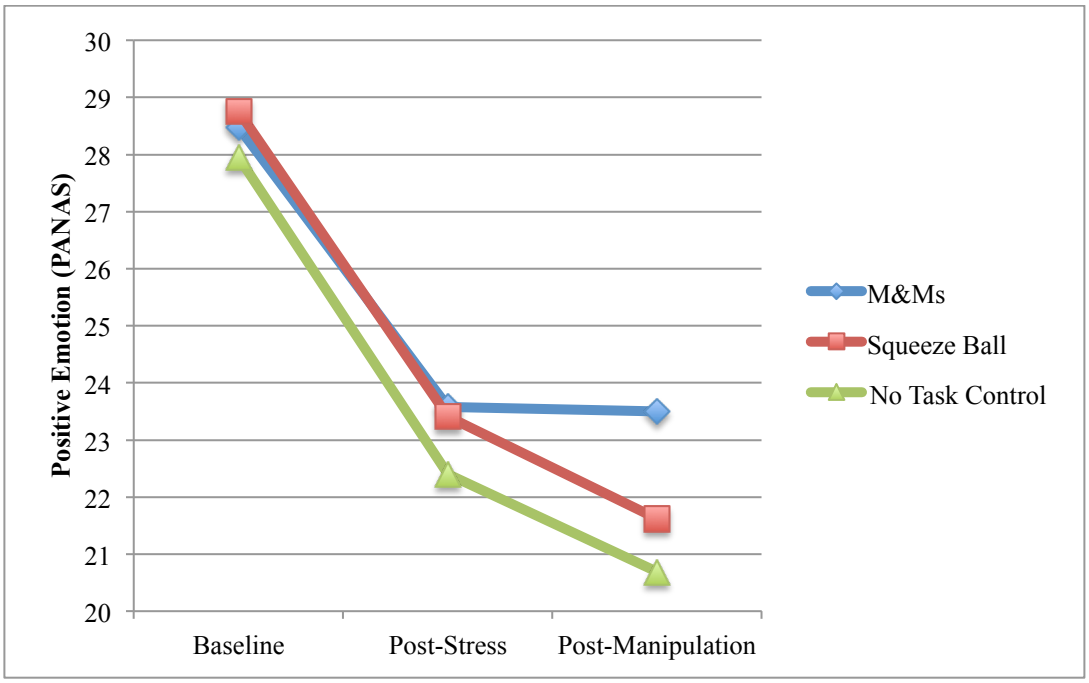


Figure 4B

Effect of Gender on Change in Positive Emotion Over Time

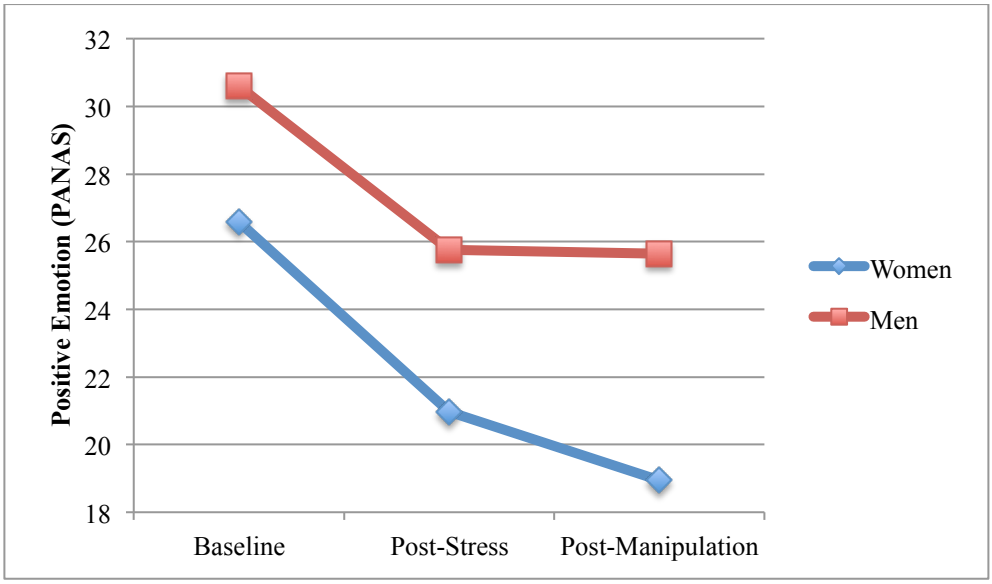
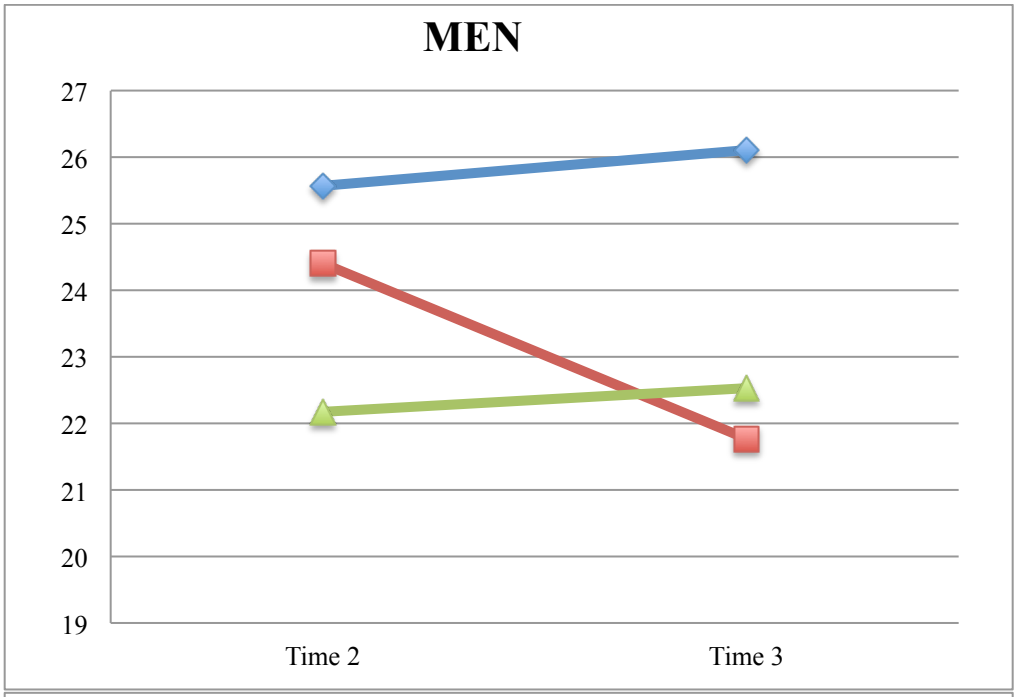


Figure 4C

Effect of Gender and Emotion Regulation Group on Change in Positive Emotion Over Time



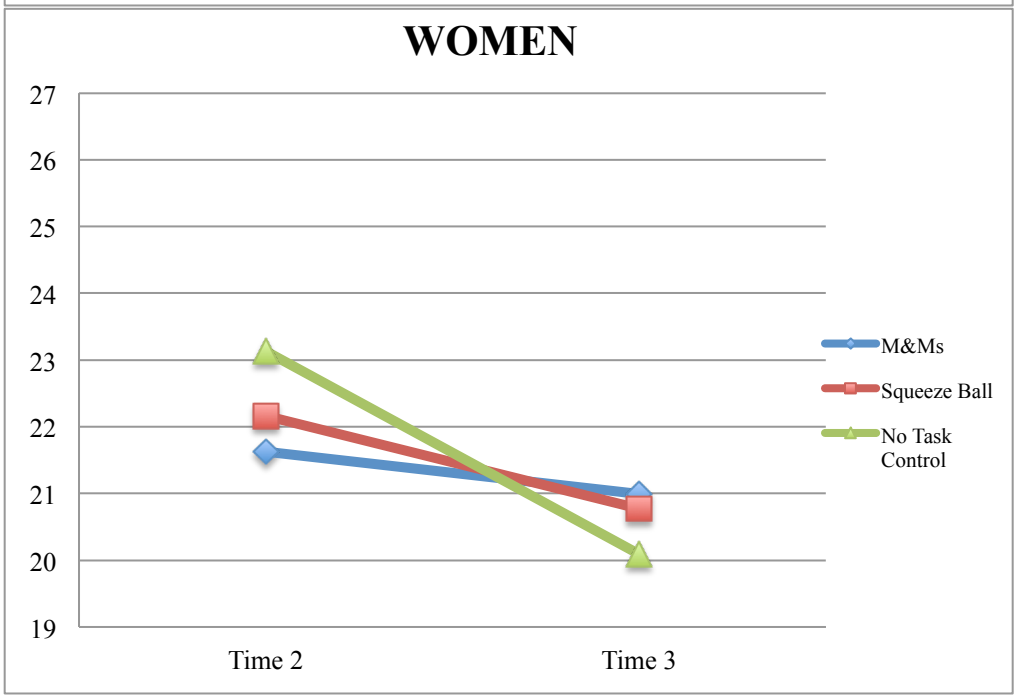


Figure 5A

Effect of Emotion Regulation Group on Change in Momentary Rumination

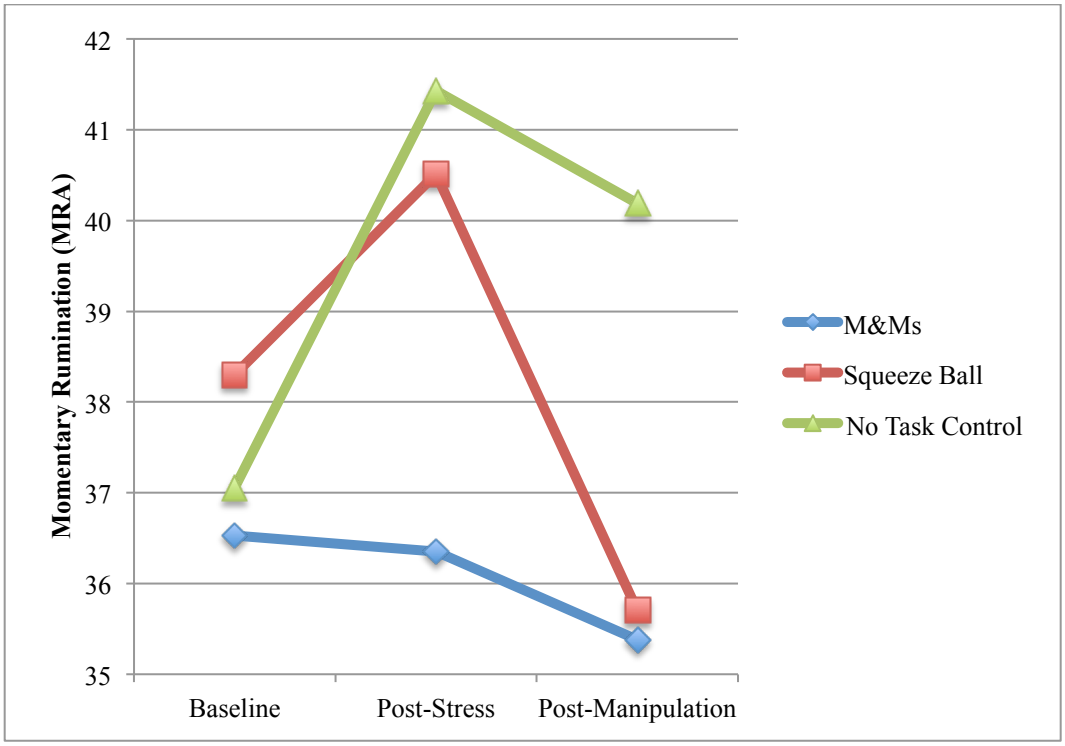


Figure 5B

Effect of Gender on Change in Momentary Rumination Over Time

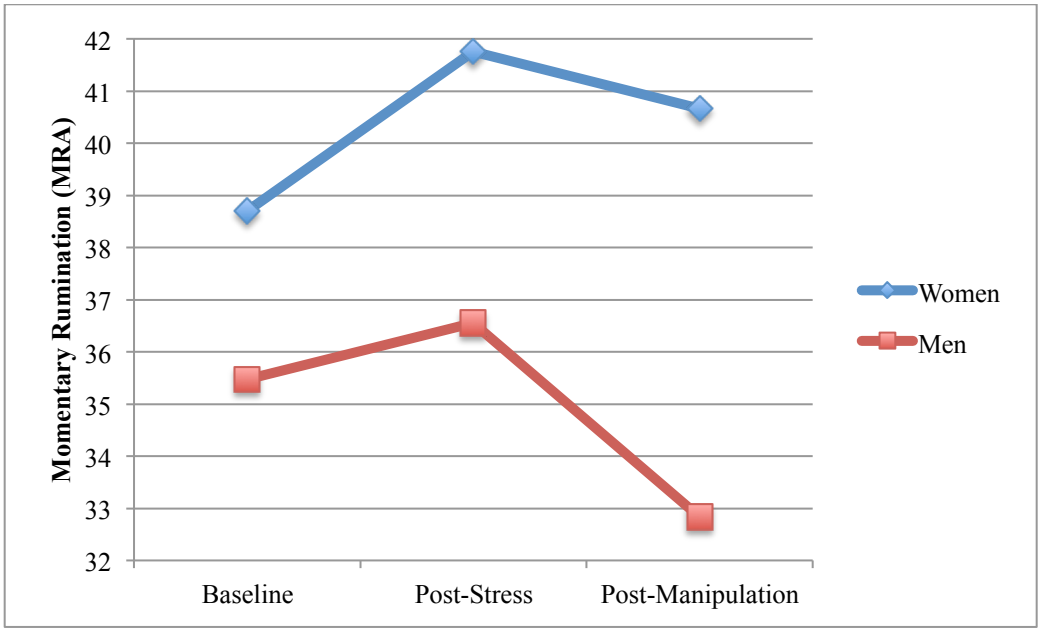


Figure 5C

Effect of Gender and Emotion Regulation Group on Change in Momentary Rumination Over Time

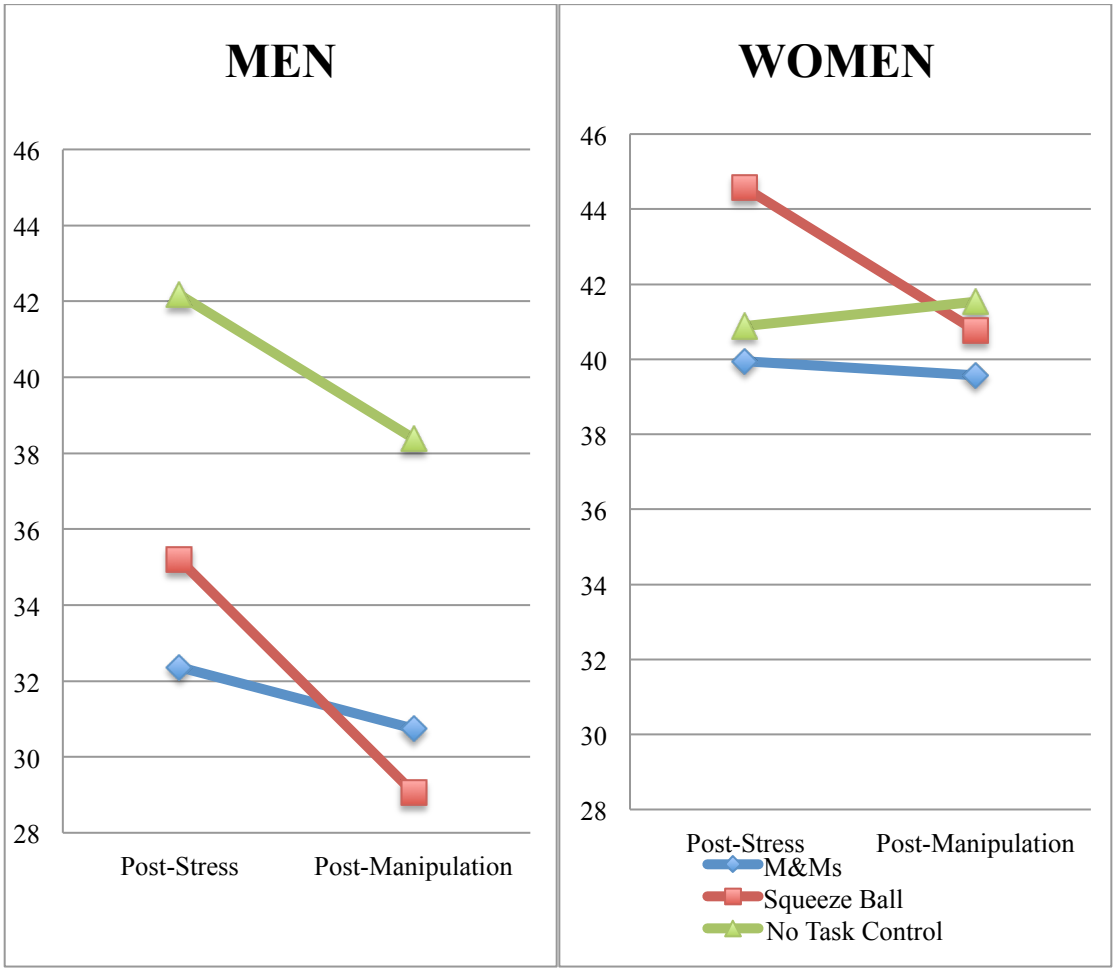


Figure 5D

Change in negative and positive emotion by state rumination level over time