LOYOLA UNIVERSITY CHICAGO

PAYING MIND TO SAVORING:
NEURAL CORRELATES AND INTERVENTION TARGETS

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CHAPTER 1

CHAPTER ONE: INTRODUCTION

1.1 Positive emotion dysregulation in depressive disorders

Major Depressive Disorder (MDD) is one of the most common psychological disorders (Goodwin et al., 2006). In the United States, 17% of adults experience at least one major depressive episode during their life (Kessler et al., 2005). Depression symptoms are associated with life impairments including interpersonal relationship strain, increased likelihood of poor work performance and burnout, and decreased physical wellbeing (Druss et al., 2009; Kessler et al., 2006; Lewinsohn et al., 2003). In the United States, depression-related loss in work productivity has been estimated to exceed $36 billion (Kessler et al., 2006). Treatment outcomes for depression suggest that even after the completion of therapy, 54% of individuals relapse within two years following treatment (Vittengl et al., 2007). Depression is currently a highly intractable disorder with a high rate of recurrence and relapse. Translational research that strives to develop a better understanding of factors that contribute to ongoing symptoms and relapse is urgently needed to develop effective treatments.

Impaired capability to regulate negative emotions is considered a robust feature of depression. Previous emotion regulation research has predominantly focused on downregulating negative emotions to decrease sadness and negative affect and has largely overlooked the role of positive emotion regulation (Joormann & Stanton, 2016). Yet, above and beyond other depression symptoms, anhedonia (i.e., lack of pleasure) is a hallmark feature of MDD (Association, 2013b), and may be associated with impairments in positive emotion regulation (Joormann & Stanton, 2016). Anhedonia negatively impacts daily function, predicts poor treatment response, indicates risk for future depressive episodes, and shows specificity with regard to depression diagnosis (Khazanov et al., 2019; Watson

& Naragon-Gainey, 2010). Anhedonia involves abnormal bi-directional reactivity and regulatory affective processes including 1) positive attenuation, or hyporeactivity to positive stimuli (Bylsma et al., 2008; Forbes & Dahl, 2005) and 2) impaired capability to enhance or upregulate affective responses evoked by positive stimuli (Forbes & Dahl, 2005). Broadly defined, emotion regulation refers to the psychological processes that modulate an initial emotional response (Lewis et al., 2010) and implies that a change has occurred from initial reactivity (i.e., baseline affective response to a stimulus). Emerging research on positive emotion dysregulation in depression indicates that impaired regulatory mechanisms may diminish the frequency, duration, intensity, and quality of positive emotions, including difficulties anticipating, initiating, sustaining, or upregulating positive stimuli and experiences (Forbes & Dahl, 2005; Joormann & Stanton, 2016; Liu & Thompson, 2017).

Experiencing positive emotions is paramount to deriving vitality from daily lived experiences. Positive emotions are associated with a range of beneficial intertwined psychological and physical outcomes including longevity, reduced incidents of stroke, improved sleep quality, larger social networks, increased prosocial behavior, lower cortisol levels, and increased endogenous opioids and oxytocin (Silton et al., 2020). However, only limited research has focused on understanding positive emotion regulation within the context of depression. Moving forward, a new focus on developing evidence-based strategies to target impairments in positive emotion regulation in depression could be critical to improving the low treatment outcome rate in depression.

1.2 Savoring strategies upregulate positive emotions in depression.

Savoring-based regulatory strategies are the most commonly used strategies implemented to sustain and upregulate positive emotions (Heiy & Cheavens, 2014; Liu & Thompson, 2017). First coined by Bryant (1989), savoring refers to the capacity "to attend to, appreciate, and enhance the positive experience in one's life" (Bryant & Veroff, 2007). People initiate savoring responses in reaction to a positive event or feeling as a way to maintain, intensify, or prolong the initial positive experience (Bryant & Veroff, 2007). While savoring, one may eagerly anticipate future positive experiences, focus on ongoing positive experiences as they occur in the present moment, or reminisce about past positive experiences. Regardless of the temporal focus, savoring processes upregulate positive emotions in the present moment. Savoring strategies that amplify positive emotions are associated with greater frequency of positive affect (Smith et al., 2014) and the capacity to savor is positively associated with extraversion, self-esteem, happiness, and life satisfaction (Bryant, 2003). Correspondingly, lack of savoring capacity is inversely correlated with anhedonia, depression, hopelessness, and neuroticism (Bryant, 2003), indicating that the capability to upregulate positive emotions likely involves modifiable processes that are vulnerable to change in depression (Silton et al., 2020).

With specific relevance to depression, studies aimed at enhancing savoring capacity show that enriching any of the three temporal domains of savoring (reminiscing, savoring the moment, or anticipating) is associated with increased frequency and intensity of positive affect, and decreased negative affect (Bryant & Veroff, 1984, 2007). Training on momentary positive emotion regulation (i.e., memory building, expressing positive emotions) resulted in decreased self-reported depression symptoms when compared to a control group after two weeks (Hurley & Kwon, 2012). A savoring intervention study that was conducted in older adults showed that diminished dampening of positive emotions was related to decreased depression symptoms (J. L. Smith & Hanni, 2017). Savoring may improve the capability to recognize and enjoy positive moments, even during difficult times (J. L. Smith & Hanni, 2017). Positive self-attributions for recent positive events have been associated with attenuated depression symptoms and enhanced positive affect following positive events in a sample of college-aged women (McMakin et al., 2011). Increased attention to positive stimuli is a candidate psychological mechanism through which positive emotion regulation strategies are theorized to mitigate depression symptoms (Carl et al., 2013; Joormann & Stanton, 2016).

1.3 Mindfulness-based interventions may increase capacity for positive emotion regulation in individuals with depression.

While savoring and mindfulness are not analogous, there may be some overlapping conceptual aspects (Bryant & Smith, 2015; Bryant & Veroff, 2007; Hurley & Kwon, 2012). Mindfulness meditation practices and mindfulness-based interventions emphasize the importance of cultivating non-judgmental attention and awareness in the present moment (Gu et al., 2015), which may help enhance the capability to savor the moment. Mindfulness meditation is theorized to enhance the capacity for and experience of positive emotions (Garland et al., 2015; Wielgosz et al., 2019) and ultimately promote wellbeing (Dahl et al., 2015), as well as broaden cognitive scope which in turn bolsters the capacity for savoring (Garland et al., 2015). Mindfulness meditation practices may modify positive valence systems through enhanced emotion awareness, modulations in emotional reactivity, increased use of cognitive reappraisal, and alterations in reward processes (Wielgosz et al., 2019). Along with increasing attention and awareness toward positive experiences as they occur, positive reappraisal may be a key emotion regulation mechanism related to mindfulness meditation practice that reduces stress and depression symptoms (Garland et al., 2015).

Headspace is the top-rated mindfulness app per psyberguide.org. It is also scalable and cost-effective. Additionally, out of 23 commonly used mindfulness-based mental health apps, researchers awarded Headspace with the highest rating on the Mobile Application Rating Scale, which assesses app engagement, functionality, aesthetics, information quality, and subjective satisfaction (Mani et al., 2015). Since the onset of this study, Headspace has provided our study team with free three-month Headspace access codes for study participants and they also share all user-data for study participants. Headspace otherwise provides no other financial support for this research. The present study aims to advance our understanding of self-report wellbeing and neurophysiological outcomes that index changes in depression and positive emotion regulation following an eight-week trial of Headspace.

1.4 Establishing the neural correlates of positive emotion regulation.

Previous affective neuroscience research rarely focused on reaction and response to positive emotion; thus, we presently have a minimal understanding regarding the neural correlates associated with positive emotion regulation, which remains a critical area of research to attend to moving forward15. Our research team conducted an electroencephalography (EEG) study to validate and establish the emotion regulation task used in the present study. This research was fundamental to improving our understanding of the temporal course of the neural correlates of positive emotion reactivity and regulation. We pre-registered this previous EEG study, and consistent with open science practices, we will make the data publicly available (OSF link: https://osf.io/p5ba9). This research focused on two key event-related potential (ERP) components which provide information about the temporal course of neural activity involved in processing affective stimuli: the early posterior negativity (EPN) and the late positive potential (LPP) in response to positive emotion reactivity and regulation. The EPN represents an early categorization of affective stimuli whereas the LPP is indicative of a later integrated conceptual analysis (Frank & Sabatinelli, 2019). LPP is an established index of emotional arousal in response to visual stimuli (Hajcak et al., 2010; Sabatinelli et al., 2005) and is theorized to index a visual cortical/amygdala pathway that is involved in evaluating the affective salience of a stimuli34. Increased LPP has been associated with increased subjective reports of emotional arousal (Foti & Hajcak, 2008). Therefore, we expected that the capability to flexibly modulate emotional intensity in response to positive stimuli would be indexed by LPP, which would be associated with increased positive emotion regulation capacity (per self-report).

Primary study aim: We will evaluate the hypothesis that an eight-week app-based mindfulness meditation intervention will modify neural correlates of positive emotion regulation for individuals with depression symptoms. Building upon emerging research from my laboratory that characterizes patterns of brain activity associated with positive emotion regulation and savoring the moment (Kahrilas et al., n.d.), the proposed project will evaluate whether an eight-week Headspace mindfulness intervention modifies the neural correlates of positive emotion regulation in individuals with depression symptoms. Specifically, the proposed study will evaluate whether the capability to modulate emotional intensity in response to positive stimuli (as indexed by EPN and LPP) will be increased for emerging adults with depression following eight weeks of Headspace use. Illustrating proof of concept and feasibility for the proposed research, our preliminary analyses demonstrate that Headspace reduces depression symptoms and increases momentary savoring capacity (Conley et al., 2019; Silton et al., 2018). Significance

Cultivating the capacity to experience positive emotions via upregulating the experience associated with positive stimuli and moments as they occur is critical to psychological and physical health outcomes. The proposed study will examine indices of neural (EEG) function and their association with positive emotion regulation capabilities in order to identify potential mechanisms. This broad aim is consistent with the National Institute of Mental Health (NIMH) Research Domain Criteria (RDoC) initiative which encourages researchers to integrate across units of analysis in order to better characterize dimensional perspectives on human behavior. Identifying modifiable psychological mechanisms associated with positive emotion regulation is critical to advancing evidence-based therapeutic approaches that promote societal health and wellbeing, particularly in the present milieu of rapidly increasing rates of depression and anxiety disorders (World Health Organization, 2014). As such, this research has the potential to inform interventions to enhance physical wellbeing and psychological vitality in individuals with medical and psychological disorders, such as depression, postpartum depression, and pain disorders. Furthermore, this project will provide opportunities to mentor graduate and undergraduate research assistants. Through mentoring in human neuroscience research, students will build a broader skill set involving data science, critical thinking, development of innovative ideas, project management, and communication abilities that will prepare them for successful careers in psychological or health sciences.

CHAPTER 2

CHAPTER TWO: SAVORING THE MOMENT: A LINK BETWEEN AFFECTIVITY AND DEPRESSION

2.0.1 Introduction

Affective theories of mood and anxiety disorders have posited that low positive affectivity is a specific risk factor for depression (Clark & Watson, 1991; Lewinsohn & Graf, 1973; Watson, Weber, et al., 1995; Watson, Clark, et al., 1995), whereas high negative affectivity may be a more general indicator of distress that is observed across depression and anxiety disorders, as well as other psychopathology types (Watson & Clark, 1984). Positive affectivity reflects a tendency to experience intense and frequent episodes of pleasant moods (Watson, 2009), while negative affectivity refers to a tendency to experience negative moods (Watson & Clark, 1984). Positive and negative affectivity are theorized to represent stable individual differences indicative of an individual's disposition to experience positive and negative affect (i.e., transient emotional experiences) respectively. To this extent, positive affectivity and negative affectivity are closely associated with highly stable personality traits such as extraversion and neuroticism, correspondingly (Costa & McCrae, 1980; Warr et al., 1983). While certain major life events (e.g., unemployment, disability) are associated with long-term changes in subjective well-being, others (e.g., marriage, widowhood, divorce) only have short-term effects with a tendency to revert back to baseline levels of positive affectivity following these major events (Lucas, 2007; Suh et al., 1996; Watson, 2009). With regard to depression, the frequency of positive life events is not fully explanatory of depression symptoms (Needles & Abramson, 1990). Rather, the relationship between positive events and depression symptomatology is likely modulated by individual differences ranging from cognitive style (Needles & Abramson, 1990) to neurobiological factors (Watson, 2009) that influence the interpretation and/or experience of positive events. Related, research has indicated that emotional inertia (i.e., degree to which one's affective state is predicted by a previous affective state) may be a risk factor for future development of mood disorders (Koval et al., 2012; Kuppens et al., 2010). Research has also concurrently indicated that affective instability is related to depression symptoms (Thompson et al., 2012). Seeking to reconcile these findings, research utilizing experience sampling and controlled laboratory methods found that more resistant negative emotion, specifically, was related to depression while positive emotion continues to fluctuate (Koval et al., 2013). While research has explored the role of negative emotion regulation strategies (e.g., reappraisal, acceptance, problem solving; Aldao et al., 2010) in the context of depression, the same cannot be said about positive emotion regulation (Silton et al., 2020). Characterizing specific positive emotion regulation strategies that mediate the relationship between affectivity and depression could inform treatment and intervention approaches to depression.

2.0.2 Emotion Regulation and Depression

The connection between negative emotion regulation and depression is well established (Gross, 1998b; Gross & Muñoz, 1995; Joormann & Gotlib, 2010; Joormann & Vanderlind, 2014; Nolen-Hoeksema et al., 1993). Individuals with depression are more likely to engage in maladaptive regulation strategies such as rumination, expressive suppression, and catastrophizing and less likely to utilize adaptive strategies like reappraisal and self-disclosure compared to individuals without depression (Garnefski & Kraaij, 2007; Gross & John, 2003; Joormann & Gotlib, 2010). More recently, research has begun to examine the influence of positive emotion regulation on depression symptoms (Feldman et al., 2008; Nelis et al., 2015; Raes et al., 2012; Werner-Seidler et al., 2013). Beck (1979) theorized that dampening positive emotions intensifies and perpetuates depression. Accordingly, greater dampening of positive affect is prospectively associated with increased depression symptoms three and five months later (Raes et al., 2012). Other research has shown that those with depression tend to be apprehensive about experiencing positive affect and thus engage in maladaptive emotion regulation strategies, such as dampening positive affect (Werner-Seidler et al., 2013). Furthermore, Werner-Seidler et al. (2013) showed that depression symptoms are inversely related to strategies implemented to amplify positive affect and depression. In sum, although research is beginning to establish that those with depression tend to engage in maladaptive positive emotion regulation strategies that reduce positive emotion (Carl et al., 2013; Garnefski & Kraaij, 2007; Gross, 2013; Silton et al., 2020), there has been less focus on identifying strategies that may successfully enhance positive emotion in individuals who are at risk for depression. As such, the present study evaluates the hypothesis that savoring may ameliorate depression symptoms.

2.0.3 Savoring Responses and Savoring Beliefs

Savoring refers to an awareness of positive experiences and the use of positive emotion regulation strategies to enhance and extend positive feelings that are derived from those experiences (Bryant et al., 2011; Bryant, 1989; Bryant & Veroff, 2007; J. L. Smith & Bryant, 2017). People initiate savoring responses in reaction to a positive event or affect as a way to maintain, intensify, or prolong positive experience (Bryant & Veroff, 2007). The original conceptual formulation of savoring (Bryant & Veroff, 2007) is predicated on the theory that people typically engage in savoring responses in reaction to positive events or affect, which people regulate through cognitive or behavioral strategies. Chronically low levels of positive affectivity would be expected to reduce savoring responses, which over time would lower self-evaluations of savoring ability. While savoring, one may anticipate the enjoyments of future positive experiences, focus on ongoing positive experiences as they occur, or reminisce about past positive experiences. Regardless of the temporal focus, savoring processes regulate positive emotions in the present moment. In contrast to savoring responses, savoring beliefs are self-perceptions of one's capacity to savor (Bryant, 2003). Although related to ways in which people regulate positive feelings in response to positive events, savoring beliefs are dispositional tendencies that are distinct from specific savoring strategies in which people engage. Stronger savoring beliefs are associated with lower levels of depression symptoms (Bryant, 2003; Eisner et al., 2009; Hou et al., 2016; Ramsey & Gentzler, 2014; Smith & Hollinger-Smith, 2015). Examining the correlations between savoring beliefs and depression in two separate samples, Bryant (2003) found a significant negative correlation between savoring the moment and depression in both samples, a significant negative correlation between positive reminiscence and depression in one of the samples, and no correlation between positive anticipation and depression in either sample. In another study, savoring the moment, but not anticipation, was also identified as a unique predictor of lifetime depression symptoms (Carver & Johnson, 2009). These results suggest that the capacity to savor ongoing positive experiences as they occur may have the strongest relationship with level of depression symptoms. Furthermore, those endorsing higher levels of savoring beliefs report similar experiences as those endorsing high levels of positive affectivity—namely, intense and frequent episodes of positive affect (Bryant & Veroff, 2007; Watson, 2009).

2.0.4 Savoring and Positive Affect

Savoring strategies that amplify positive emotions are associated with greater frequency of positive affect (Gentzler et al., 2013; Quoidbach et al., 2010; Smith et al., 2014). As an example, college students who reminisced for one week using either memorabilia or cognitive imagery reported greater increases in frequency of happy feelings compared to participants in a control condition (Bryant et al., 2005). In addition, a present-focused savoring strategy, mindfully photographing beautiful or meaningful subjects, led to more positive moods compared to photographing neutral subjects (Kurtz, 2015). Research has also found that greater savoring beliefs are associated with higher intensity of positive affect and less negative affect (Bryant, 2003; Smith & Bryant, 2013). Across two separate samples, people who reported stronger savoring beliefs also tended to report higher levels of personality traits associated with increased positive affect, such as intensity of happy feelings, self-esteem, frequent happy feelings, and less frequent unhappy feelings (Bryant, 2003). Using experience sampling methodology, (2012) found that momentary savoring mediated the relationship between daily positive events and momentary happiness, and this effect was stronger for people with higher trait levels of amplifying (i.e., broad types of savoring strategies) and weaker for people with higher trait levels of dampening. Research has also shown that a combination of low capacity to savor the moment and experiencing less positive events is most strongly associated with lower positive affect and less life satisfaction (Hurley & Kwon, 2013; Jose et al., 2012). Collectively, these studies illustrate that higher savoring capacity results in greater frequency and intensity of positive affect, which is representative of elevated positive affectivity. However, while this research has investigated the relationship between savoring beliefs and trait-like attributes such as intensity and frequency of affect and increased self-esteem, previous research has not explicitly examined the relationship between trait affectivity and savoring beliefs within the context of depression. The present study evaluates savoring as a positive emotion regulation strategy that may modify low positive affectivity and thus reduce depression symptoms.

2.0.5 The Focus of the Present Study

A variety of interventions have been developed that focus on each of the three temporal domains of savoring (i.e., reminiscing, savoring the moment, and anticipating) in an effort to boost happiness (Smith et al., 2014). For example, cultivating the ability to imagine future positive events can enhance anticipating (Quoidbach et al., 2009), taking mindful photographs aids in momentary savoring (Kurtz, 2015), and increasing awareness of recent positive events serves to bolster reminiscing (Seligman et al., 2005). Thus, if savoring mediates the relationship between affectivity and depression, it may be an effective and modifiable target for bolstering positive affectivity and reducing depression symptoms. Common treatments for depression, including cognitive behavioral therapy (CBT) and antidepressant medication (Price & Drevets, 2010), leave considerable room for improvement that may be fulfilled by focusing on enhancing PA. These treatments predominantly focus on ameliorating distorted thought patterns and neurotransmitter systems pertaining to negative emotions (Argyropoulos & Nutt, 2013; Beck, 1979). Approximately 45-65% of those with depression undergoing CBT do not achieve remission (DeRubeis et al., 2005; Dimidjian et al., 2006). The importance of enhancing PA is corroborated by the fact that patient definitions of depression recovery equally emphasize repair of PA and NA (Demyttenaere et al., 2015). Further, Dunn and colleagues (2019) conducted two separate studies investigating the efficacy of therapeutic and pharmacological approaches to treating depression and mitigating high NA and PA. Results indicated that NA and PA were both uniquely related to depression and that current treatments (CBT, selective serotonin reuptake inhibitors, selective norepinephrine reuptake inhibitors, tricyclic antidepressants, and monoamine oxidase inhibitors) improve NA, but do little to bolster PA (Dunn et al., 2019). This is despite the fact that reductions in PA were more marked than elevated NA in the samples tested, indicating that PA may be a more pressing intervention target (Dunn et al., 2019). Novel treatments have theorized that increased use of dampening appraisals may be a psychological mechanism of reduced PA (Dunn et al., 2018). This implicates positive emotion regulation and savoring, which is underscored by literature illustrating that greater savoring beliefs are correlated with lower levels of depressive symptoms (Bryant, 2003; Eisner et al., 2009; Hou et al., 2016; Ramsey & Gentzler, 2014; Smith & Hollinger-Smith, 2015). A more thorough understanding of the mechanisms of PA and savoring may pave the way for improving depression treatments. The present study characterizes the relationship between affectivity, savoring beliefs, and depression symptomatology. We evaluated the following hypotheses: 1) replicating past research, positive affectivity will be negatively associated with depression symptoms and negative affectivity will be positively associated with depression symptoms, 2) positive affectivity will be positively associated with all three temporal domains of savoring and negative affectivity will be negatively associated with all three temporal domains of savoring, 3) savoring the moment will be distinctly associated with depression, and 4) savoring the moment will distinctly mediate the relationship between affectivity and depression. Despite the present study's focus on PA, mitigating NA remains an important factor to address in depression, with research demonstrating that both are independently related to depression symptoms (Dunn et al., 2019). Additionally, given the negative associations that exist between stable negative traits and savoring (e.g., neuroticism; Bryant, 2003), NA was included as an exogenous variable in the exploratory path analysis. Further, including NA facilitates the analysis of PA and NA's unique relationship with depression via the temporal domains of savoring by statistically controlling for the effects of the other. Because anxiety and depression symptoms frequently co-occur (Association, 2013a; Clark, 1989; Mineka et al., 1998), we accounted for the effects of anxiety by including measures of anxious arousal (somatic) and anxious apprehension (worry) symptoms (Sharp et al., 2015) in our analyses. Additionally, research suggests that worry spans temporal domains and is associated with rumination about past events and hopelessness regarding the future (Andrews & Borkovec, 1988; MacLeod & Byrne, 1996) as well as procrastination (Stöber & Joormann, 2001), each of which may overlap with the temporal domains of savoring. Further, since research indicates that females tend to report greater savoring capacity than do males (Bryant & Veroff, 2007), gender was included as a covariate. The present study utilized a parallel mediation model with cross-sectional data. Some researchers have advocated against this practice since correlational data do not afford causal interpretation (Maxwell et al., 2011). Alternatively, Hayes (2018) advocated for a more relaxed stance: "We should not let the limitations of our data collection efforts constrain the tools we bring to the task of trying to understand what our data might be telling us about the processes we are studying" (p. 18). Many researchers share this sentiment as indicated by their use of mediation analyses with cross-sectional data (Blashill & Vander Wal, 2010; Gaunt & Scott, 2014; Goodin et al., 2009; Kung et al., 2016; Lee et al., 2014; Li et al., 2011; Osborne et al., 2015; Pollack et al., 2012; Rees & Freeman, 2009; Smith et al., 2016; Thai et al., 2016; Thomas & Bowker, 2015; Torres & Taknint, 2015; Webb et al., 2016). Thus, the present study utilized cross-sectional mediation analyses while recognizing its preclusion of causal inference.

2.1 Method

2.1.1 Participants

Participants (N = 2,482) were recruited from introductory psychology courses. Participants received course credit for completion of an online survey. Case wise deletion was used to omit participants (n = 864) that had missing responses to any questionnaires used in the present study. The final sample of 1,618 participants (n = 375 males, n = 1,243 females) ranged in age from 17 - 40 (M = 18.99 years, SD = 1.33) and was 70.0% Caucasian, 19.1% Asian, 4.5% Black or African American, 0.9% Native Hawaiian or other Pacific Islander, 0.7% American Indian or Alaskan Native, and 4.9% Biracial; 11.4% reported that they were Hispanic/Latinx and 88.6% were not Hispanic/Latinx. The study was approved by the University's Institutional Review Board, and informed consent was provided to all participants prior to beginning the survey.

2.1.2 Questionnaire Measures

Savoring capacity. We administered the Savoring Beliefs Inventory (Bryant, 2003) to assess participants' savoring capacity. The SBI measures the perception of one's ability to feel pleasure through anticipating positive experiences, savoring positive moments as they occur, and reminiscing about past positive events (Bryant & Veroff, 2007). The SBI was analyzed as three eight-item subscales pertaining to temporal forms of savoring: anticipating (e.g., "Before a good thing happens, I look forward to it in ways that give me pleasure in the present."), savoring the moment (e.g., "I know how to make the most of a good time."), and reminiscing (e.g., "I enjoy looking back on happy times from my past."). Items are rated on a seven-point Likert scale from "1" (strongly disagree) to "7" (strongly agree). The three temporal subscales of the SBI were originally conceived as separate, intercorrelated measures of individuals' characteristic capacities to savor. Test-retest reliability assessments provide cross-cultural evidence for the stability of the SBI subscales (Bryant, 2003; Kawakubo et al., 2019). Prospective research testing predictive validity found that participants' SBI scores predicted ability to anticipate, momentarily savor, or reminisce upon winter break three months later (Bryant, 2003). This empirical evidence collectively supports the conclusion that the three SBI subscales reflect stable traits that manifest themselves in predictable forms of behavioral and emotion experience over time. Bryant (2003) found moderate to high internal consistency across all three subscales. The present study replicated these findings (Anticipating, $\omega = .87$; Savoring the Moment, $\omega = .85$; and Reminiscing, $\omega = .86$). *Depression severity.* To evaluate depression severity, the nine-item Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001) was administered. PHQ-9 items are scored from "0" (not at all) to "3" (nearly every day) and are based on the depression criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition. Internal consistency of the PHQ-9 in the present study ($\omega = .87$) was consistent with past research (Kroenke et al., 2001). *Affectivity and anxiety symptoms.* To assess for positive and negative affectivity as well as anxiety, the 39-item Mood and Anxiety Symptoms Questionnaire (Watson, Weber, et al., 1995; Watson, Clark, et al., 1995) was administered. The MASQ was analyzed as three separate subscales: the eight-item negative affectivity (NA) Scale (MASQ-NA8; e.g., "Felt withdrawn from other people"), the 14-item positive affectivity (PA) Scale (MASQ-PA14; e.g., "Felt cheerful"), and the 17-item Anxious Arousal Scale (MASQ-AA; e.g., "Startled easily"). Previous literature has supported these oblique factors in two independent samples of individuals at-risk for depression and anxiety (Kendall et al., 2015; Nitschke et al., 2001). Participants rated their affectivity and anxiety symptoms using a five-point Likert scale from "1" (not at all) to "5" (extremely). Consistent with previous research (Bredemeier et al., 2010), the MASQ scales demonstrated good to excellent internal consistency(MASQ-NA8, $\omega = .80$; MASQ-PA14, $\omega = .94$; and MASQ-AA, $\omega = .88$). *Worry.* The 16-item Penn State Worry Questionnaire (Meyer et al., 1990) was used to assess for the trait of worrying. PSWQ items are rated on a five-point Likert scale from "1" (not at all typical) to "5" (very typical).

Table 2.1
Descriptive Statistics Among Positive and Negative Affectivity and Savoring the Moment for each Depression Severity Group

			Positive Affectivity			Negative Affectivity			Savoring the Moment		
Depression Group	n	%	Mean	*SD*	ω	Mean	*SD*	ω	Mean	*SD*	ω
Minimal	613	37.9	47.9	10.8	.93	14.8	4.2	.70	43.9	7.8	.81
Mild	561	34.7	43.2	10.2	.92	18.4	4.5	.65	40.3	8.3	.83
Moderate	269	16.6	38.9	10.3	.91	23.0	4.2	.50	35.9	8.0	.78
Moderately Severe	125	7.7	34.5	11.3	.93	26.3	4.3	.49	31.5	8.7	.82
Severe	50	3.1	33.0	14.6	.96	29.3	4.8	.55	27.9	9.4	.83

Note. Holm corrected pairwise t-tests indicated significant differences between each depression group for all variables except between moderately severe and severe groups for PA. SD = standard deviation, ω = McDonald's Omega.

Meyer and colleagues (1990) found a high degree of internal consistency in the PSWQ, and the present study found good consistency ($\omega = .87$).

2.2 Results

2.2.1 Depression Severity

To provide clinically relevant descriptive information regarding depression severity in the sample, participants were categorized into five depression severity groups based on established PHQ-9 cutoff scores: minimal (1-4), mild (5-9), moderate (10-14), moderately severe (15-19), and severe (20-27; Kroenke et al., 2001). Group means, standard deviations, and reliability coefficients of primary variables of interest (PA, NA, and savoring the moment) were calculated for each of the depression severity groups (see **??**). Pairwise t-test comparisons with Holm correction were conducted to assess mean differences between each depression group for PA, NA, and savoring the moment. Analyses indicated significant differences between all groups for all variables except for the difference in mean PA between moderately severe and severe depression groups.

Table 2.2
Correlations among affectivity, temporal domains of savoring, depression severity, and anxious arousal measures (N = 1,618)

	1.	2.	3.	4.	5.	6.	7.	8.
1. Anticipating								
2. Savoring the Moment	.68							
3. Reminiscing	.75	.72						
4. Positive Affectivity	.45	.59	.46					
5. Negative Affectivity	-.36	-.55	-.39	-.40				
6. Anxious Arousal	-.28	-.31	-.28	-.07	.58			
7. Depression	-.34	-.51	-.36	-.42	.74	.54		
8. Worry	-.12	-.32	-.16	-.20	.46	.35	.46	

2.2.2 Correlations Among Study Variables

Pearson correlations were computed among the primary study variables (see Table 2). As expected, PA was positively associated with all temporal domains of savoring. NA, depression, and anxious arousal were negatively associated with all temporal savoring domains. All correlations were statistically significant.

2.2.3 Positive Affectivity, Negative Affectivity, and Anxious Arousal as Predictors of Depression

The tripartite model posits that depression and anxiety have specific relations with three affective dimensions: PA, NA, and anxious arousal (Clark et al., 1995; Watson, Clark, et al., 1995). Given the present study's focus on PA and depression, we wanted to confirm the unique relation between each of these dimensions and depression symptoms in the present sample. Per the tripartite model, we anticipated that low levels of PA and high levels of NA would be positively associated with depression symptoms, and that anxious arousal would be unrelated to depression symptoms. Multiple regression analyses were conducted with PA, NA, and anxious arousal as predictors and depressions with no covariates. Diverging from the specific association between PA and depression proposed by Clark and Watson (1991, 1995a, 1995b), results from the test sample indicated that each of the predictors were uniquely associated with depression. NA [$b = .52,\ \beta = .55,\ t(1614) = 25.47,\ p < .001$] was the strongest predictor of depression, followed by anxious arousal [$b = .11,\ \beta = .21,\ t(1614) = 10.38,\ p < .001$], and lastly PA [$b = -.09,\ \beta = -.19,\ t(1614) = -10.55,\ p < .001$].

2.2.4 Mediation Analyses

Path analyses were run in R (Team, 2018) using the lavaan package (Rosseel, 2011) to assess the indirect effects of PA and NA on depression via three temporal domains of savoring capacity while accounting for the variance associated with gender, worry, and anxious arousal (see Figure 1). Exogenous variables (PA and NA) were allowed to correlate with one another, as were the residual variances of each of the temporal domains of savoring. Maximum likelihood estimation was used to estimate path coefficients, and bias-corrected bootstrap confidence intervals based on 10,000 bootstrap samples were used to estimate indirect effects of temporal domains of savoring between affectivity and depression. The fully saturated model contained 45 free parameters with zero degrees of freedom, resulting in perfect goodness of fit indices. Results (see Figure 1 and Table 3) showed that PA was associated with anticipating (standardized: $a_1 = .41$, unstandardized: $a_1 = .30$, $p < .001$), savoring the moment (standardized: $a_2 = .46$, unstandardized: $a_2 = .36$, $p < .001$), and reminiscing (standardized: $a_3 = .39$, unstandardized: $a_3 = .28$, $p < .001$). There were significant associations between NA and anticipating (standardized: $a_i = -.11$, unstandardized: $a_i = -.16$, $p < .001$), savoring the moment (standardized: $a_{ii} = -.29$, unstandardized: $a_{ii} = -.44$, $p < .001$), and reminiscing (standardized: $a_{iii} = -.16$, unstandardized: $a_{iii} = -.23$, $p < .001$). Further, savoring the moment was related to lower depression severity (standardized: $b_2 = -.07$, unstandardized: $b_2 = -.04$, $p = .024$), while anticipating and reminiscing were not. Bias-corrected bootstrap confidence intervals (based on 10,000 bootstrap samples; see Table 3) for the indirect effects of temporal domains of savoring between PA and depression did not include zero for savoring the moment (95% CI [-.028, -.002], $a_2b_2 = -.01$) but did include zero for anticipating (95% CI [-.009, .012], $a_1b_1 = .00$) and reminiscing (95% CI [-.009, .013],

$a_3b_3 = .00$). Similarly, bias-corrected bootstrap confidence intervals for the indirect effects of temporal domains of savoring between NA and depression did not include zero for savoring the moment (95% CI [.003, .035], $a_{ii}b_2 = .02$) but did include zero for anticipating (95% CI [-.007, .005], $a_ib_1 = .00$) and reminiscing (95% CI [-.011, .007], $a_{iii}b_3 = .00$). Notably, there is a negative indirect effect between PA and depression via savoring the moment with a positive relationship between PA and savoring the moment. This signifies that the positive association between PA and momentary savoring results in reduced depression scores that accounts for a portion of the significant negative relationship between PA and depression (standardized: $c'_{PA} = -.16$, unstandardized: $c'_{PA} = -.08$, $p < .001$). The direct effect of NA on depression was also significant (standardized: $c'_{NA} = .49$, unstandardized: $c'_{NA} = .02$, $p < .001$).

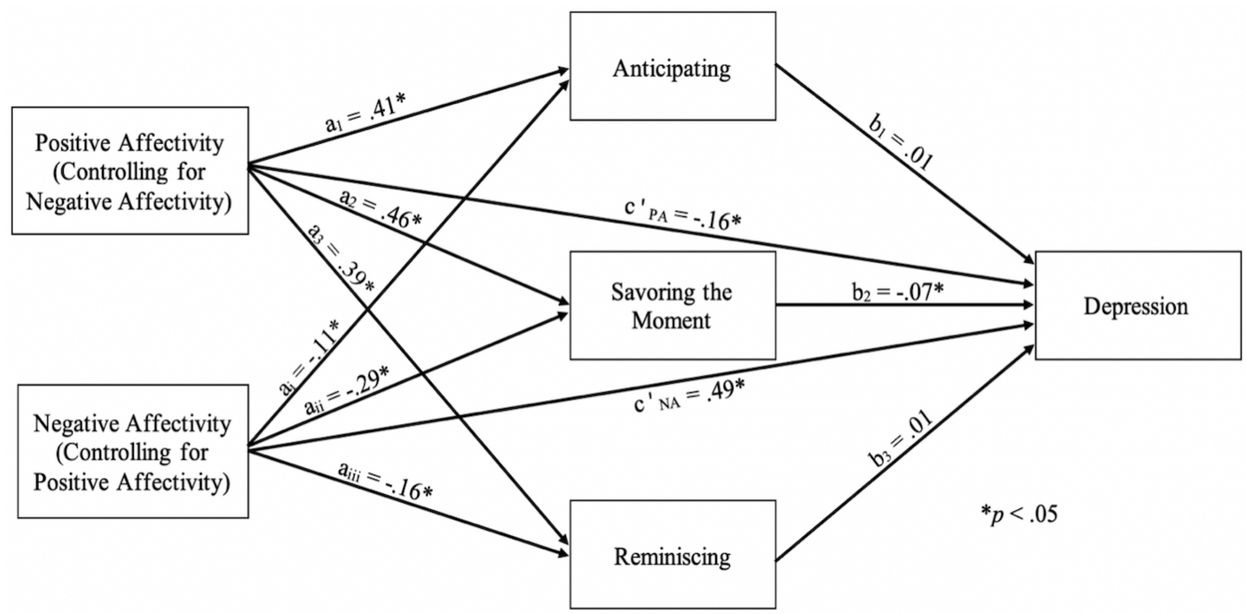

Figure 2.1. *Standardized structural diagram of path model with three mediators: anticipating, savoring the moment, and reminiscing (N = 1,618). The diagram shows A) the effect of positive and negative affectivity on depression severity and B) the direct and indirect pathways associating affectivity with temporal domains of savoring and depression. Sex, worry, and anxious arousal were included as covariates in the model, but were omitted from the figure to streamline presentation. Positive and negative affectivity were allowed to correlate with each other and with the three covariates, which were also allowed to intercorrelate. These intercorrelations were omitted from the path diagram to streamline presentation. The residual variances in the mediators and in depression were also estimated parameters in the structural model. These residual variances were also omitted from the path diagram to streamline presentation.*

Table 2.3

Unstandardized path coefficients from the structural equation model using positive and negative affectivity to predict depression with savoring subscales as mediators (N = 1,618). The structural model included three covariates (sex, worry, and anxious arousal) as exogenous independent variables, each of which had direct effects on the three mediators and depression.

		M_1(ANT)				M_2(MOM)				M_3(REM)				Y(DEP)				***Indirect Effects***		
																			95% bcCI	
Antecedent		Coef.	*SE*	*p*		Coef.	*SE*	*p*		Coef.	*SE*	*p*		Coef.	*SE*	*p*		Coef.	Lower	Upper
PA	a_1	0.30	0.02	<.001	a_2	0.36	0.02	<.001	a_3	0.28	0.02	<.001	c'_{PA}	-0.08	0.01	<.001		—	—	—
M_1(ANT)		—	—	—		—	—	—		—	—	—	b_1	0.00	0.02	0.796	a_1b_1	0.00	-0.009	0.012
M_2(MOM)		—	—	—		—	—	—		—	—	—	b_2	-0.04	0.02	0.024	a_2b_2	-0.01	-0.028	-0.002
M_3(REM)		—	—	—		—	—	—		—	—	—	b_3	0.01	0.02	0.697	a_3b_3	0.00	-0.009	0.013
NA	a_i	-0.16	0.05	<.001	a_{ii}	-0.44	0.04	<.001	a_{iii}	-0.23	0.05	<.001	c'_{NA}	0.46	0.02	<.001		—	—	—
M_1(ANT)		—	—	—		—	—	—		—	—	—	b_1	0.00	0.02	0.796	a_ib_1	0.00	-0.007	0.005
M_2(MOM)		—	—	—		—	—	—		—	—	—	b_2	-0.04	0.02	0.024	$a_{ii}b_2$	0.02	0.003	0.035
M_3(REM)		—	—	—		—	—	—		—	—	—	b_3	0.01	0.02	0.697	$a_{iii}b_3$	0.00	-0.011	0.007
Covariates:																				
SEX		2.89	0.41	<.001		1.63	0.37	<.001		2.61	0.40	<.001		0.53	0.21	0.012		—	—	—
WOR		0.06	0.02	<.006		-0.07	0.02	<.001		0.04	0.02	<.088		0.07	0.01	<.001		—	—	—
ANX		-0.18	0.02	<.001		-0.08	0.02	<.001		-0.14	0.02	<.001		0.10	0.01	<.001		—	—	—
R^2			0.29				0.48				0.30				0.61					
F			132.29				296.23				138.36				315.26					
p			<.001				<.001				<.001				<.001					

Note. *SE* = Standard Error, PA = Positive Affectivity, NA = Negative Affectivity, ANT = Anticipating, MOM = Savoring the Moment, REM = Reminiscing, DEP = Depression, WOR = Worry, ANX = Anxious Arousal. The symbols appearing to the left of the direct effects (e.g., a_1) refer to the labeled paths in Figure 2. The symbols to the left of each indirect effect coefficient represent the products of each of the constituent direct effects that compose each indirect effect. For example, symbol a_1b_1 represents the product of the direct effect of PA on ANT (i.e., a_1) and the direct effect of ANT on DEP (i.e., b_1), or $(a_1)(b_1)$.

2.3 Discussion

The present study examined the relationship between affectivity (PA and NA) and depression symptoms via the future-, present-, and past-focused temporal domains of savoring beliefs (i.e., self-reported capacity to savor by anticipating, savor the moment, and savor by reminiscing, respectively). As predicted, results showed that PA and NA were associated with all three temporal domains of savoring. Savoring the moment distinctly mediated the relationship between affectivity and depression; whereas, the other temporal domains did not mediate this relationship. Replicating past research, we also found a relationship between affectivity and depression symptoms (Chorpita, 2002; Clark & Watson, 1991; Dunn et al., 2019; Khazanov & Ruscio, 2016; Watson, Weber, et al., 1995; Watson, Clark, et al., 1995). Of note, we found that the effect size for the bivariate relationship between NA and depression (i.e., 55% shared variance) was roughly three times larger than the effect size for the relationship between PA and depression (i.e., 18% shared variance); but given that NA is theorized to be a common factor shared among depression and anxiety (Watson, Weber, et al., 1995; Watson, Clark, et al., 1995), higher NA may also be increased due to co-occurring anxiety symptoms. These findings are similar to results from a meta-analysis suggesting that low positive emotionality creates an inherent vulnerability to depression, but perhaps to a lesser degree than previously surmised (Khazanov & Ruscio, 2016). While findings from the present study imply that structured interventions aimed at enhancing any of the three temporal domains of savoring may serve to attenuate levels of NA and bolster levels of PA and well-being, only savoring the moment is likely to reduce depression symptoms. This latter finding is consistent with previous research showing that momentary savoring capacity has a stronger negative association with depressive symptoms than do reminiscing and anticipating (Bryant, 2003; Carver & Johnson, 2009). Together, these findings indicate that developing interventions to promote savoring the moment may be effective in reducing depression. When partitioned by pre-established depression severity cutoff-scores (Kroenke et al., 2001), the majority of the sample fell into minimal and mild depression groups, with significantly fewer participants in the moderate to severe groups. This result is consistent with a previous study conducted by Kroenke and colleagues (2001) that categorized a sample of 580 adult participants into groups based on PHQ-9 depression cut-off scores. It is also critical to note that 444 participants (27.5%) of the total present sample likely meet clinical criteria for a depression diagnosis as indicated by scoring 10 or higher on the PHQ-9 (Kroenke et al., 2001). Additionally, pairwise comparisons indicate that as participants increase in depression severity, levels of PA and capacity to savor the moment decrease while NA increases. This supports a dimensional conceptualization of the relationship between depression symptoms and individual difference factors, the present study indicates that a gradual decrease in PA/savoring the moment and increase in NA accompany a rise in depression severity. The present study expands on previous research that has investigated the relationship between positive emotion regulation and depression by assessing beliefs about positive emotion regulation, specifically savoring, across past, present, and future temporal domains. As such, these findings suggest that savoring the moment, as opposed to reminiscing or anticipating, may be instrumental in bolstering PA and reducing NA to ameliorate depression symptoms. This conclusion is further supported by positive psychological interventions that include training in momentary savoring strategies to reduce depression (Hurley & Kwon, 2013; McMakin et al., 2011; Smith & Hanni, 2019). In particular, a savoring-based intervention that instructed female college students with symptoms of dysphoria to make positive self-attributions for recent positive events was effective in reducing depression symptoms and sustaining positive affect following positive events (McMakin et al., 2011). In another study, participants who received training in the use of strategies for savoring the moment, such as memory building and expressing positive emotions, displayed lower depression and lower negative affect after two weeks compared to a control group (Hurley & Kwon, 2013). While interventions targeting reminiscing and anticipating may serve to increase PA and decrease NA, patients presenting with depression may require more specific treatment focused on savoring the present moment compared to a non-clinical sample. Supporting this notion, increased attention to positive stimuli is likely one mechanism through which savoring influences depression symptoms (Carl et al., 2013). Although it should be noted that savoring and mindfulness are not analogous (Bryant & Veroff, 2007), the importance of moment-to-moment awareness in treating depression is corroborated by mindfulness-based interventions (Gu et al., 2015).

2.3.1 Limitations

The present study has several limitations. First, the present results are based solely on self-report measures. Although self-report data are often inordinately criticized (Chan, 2009), such measures are not without problems. Self-report methods are prone to exaggeration or underreporting, both of which may be caused by social desirability bias, or a tendency to present oneself favorably (Fisher, 1993). While the PHQ-9 is frequently used to screen for depression and track treatment outcomes in research studies and clinical settings, the present study did not implement clinical interviews to validate the self-report data. Future research in this area might consider using a clinical interview to confirm depression diagnoses.

However, the PHQ-9 allows for a dimensional conceptualization of depression symptoms, which is likely to be more consistent with the range of affective and cognitive experiences that co-vary with depression symptoms (Levin et al., 2007). Second, the present study is limited by its cross-sectional design, which precludes unequivocal conclusions about cause and effect. To overcome this limitation, future research should aim to extend the present findings using a longitudinal, randomized control trial (RCT) design to evaluate the impact of various savoring interventions designed to specifically target each of the three temporal domains in a sample of participants with low levels of PA and depression. In addition, more research is needed to understand the extent to which mindfulness-based interventions that focus on developing moment-to-moment awareness also indirectly enhance positive emotion regulation and savoring the moment, or whether interventions specifically designed to enhance savoring of positive events in the moment effectively reduce depression. Additionally, all subscales (anticipating, savoring the moment, reminiscing) measure one's capacity to generate positive feelings in the moment while focusing on either past, present, or future positive experiences (Bryant & Veroff, 2007). Studies utilizing experience sampling methods (e.g., Koval et al., 2013) offer stronger conclusions regarding temporal fluctuations of emotion and depression symptoms. The presence of multicollinearity, or tautological logic, can be argued due to the high correlation between NA and depression in the present sample and the fact that depressed mood (NA) forms a central construct of depression. Other researchers analyzing the association between affectivity (measured with the MASQ) and depression concluded that tautological logic did not compromise their analyses (Dunn et al., 2019). Additionally, the constructs of NA and depression are theoretically distinct despite being related. NA is conceptualized as a general indicator of distress observed across depression, anxiety, and other psychopathology types(Watson & Clark, 1984). It is conceptually disparate from positive emotions; one with high NA does not necessarily also lack joy, excitement, or enthusiasm, which are hallmarks of depression (Watson & Clark, 1984). Nitschke and colleagues (2001) corroborated this conceptualization via factor analysis, illustrating that the MASQ-NA subscale overlaps with anxiety and depression factors. Other research indicates that the MASQ-PA scale is a superior means of screening for depression compared to the MASQ-NA scale, further suggesting that NA is conceptually distinct from depression (Bredemeier et al., 2010). The PHQ-9, on the other hand, was designed to map onto criteria for major depressive disorder diagnosis in the Diagnostic and Statistical Manual of Mental Disorders (Kroenke & Spitzer, 2002). As such, the PHQ-9 was formulated for use in clinical settings with robust diagnostic sensitivity (Kroenke & Spitzer, 2001, 2002). Nonetheless, further clarification on the overlap between affectivity and depression are grounds for future research. Finally, a post-hoc power analysis—using the `bmem` package (Zhang, 2014), specifying 1,000 Monte Carlo simulations, each with 1,000 bootstrap samples—indicated that the present sample provided less than optimal statistical power. In particular, our present sample (N = 1,618) yielded 60.5% power to detect a significant indirect effect of savoring the moment between PA/NA and depression via bootstrapping. Further analyses indicated that a sample size of 2,700 is required in order to reach 80% power for these indirect effects. This latter finding underscores the fact that researchers need to recruit large sample sizes to detect significant effects in complex mediation models.

2.3.2 Conclusion

This is one of the first studies to examine the degree to which the three temporal domains of savoring mediate the relationship between affectivity and depression symptoms. Interventions that focus on bolstering any of the temporal domains of savoring may benefit those with low PA or high NA. However, enhancing momentary savoring may be the critical temporal domain to consider adapting as an intervention to ameliorate depression. Overall, our results suggest that interventions targeting positive emotion regulation may have considerable benefit for clinical and non-clinical populations. In advancing this research, RCT methodology should be implemented to confirm causality and benefit among individuals with depression disorders.

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CHAPTER 3

CHAPTER THREE: THE NEUROBIOLOGICAL CORRELATES OF SAVORING

3.0.1 Positive Affectivity Influences Well-Being

Affective theories of mood and anxiety disorders have posited that low positive affectivity is a specific risk factor for depression (Clark & Watson, 1991; Kendall et al., 2015; Lewinsohn & Graf, 1973; Raes et al., 2012; Watson, Weber, et al., 1995; Watson, Clark, et al., 1995) and culprit for exacerbated course of depressive symptomatology (Clark & Watson, 1991; Davidson, 1998b; Watson et al., 2015). While high negative affectivity may be a more general indicator of distress that is observed across depressive and anxiety disorders, as well as other psychopathology types, positive affectivity reflects a tendency to experience intense and frequent episodes of pleasant moods (Watson, 2009), such as happiness, interest, energy, and self-assurance (Mineka et al., 1998; Watson & Naragon-Gainey, 2010) and has been associated with increased social activities (Watson & Clark, 1984). Negative affectivity refers to a tendency to experience negative moods, such as fear, anger, sadness, and guilt (Mineka et al., 1998) and is often associated with somatic symptoms and increased levels of psychopathology (Watson & Clark, 1984). Indeed, research has shown that individuals with depression report reduced mood shifting in response to positive film clips, as well as an attenuated startle response (theorized to be an indicator of emotional reactivity) to positive and negative film clips (Kaviani et al., 2004). Positive and negative affectivity are theorized to represent stable individual differences indicative of one's disposition to experience positive and 1 2 negative affect (i.e., transient emotional experiences) respectively. To this extent, positive affectivity and negative affectivity are closely associated with highly stable personality traits such as extraversion and neuroticism, correspondingly (Costa & McCrae, 1980; Warr et al., 1983). Even major life events that influence well-being and affect only have short- term effects, and there is a tendency to revert back to baseline levels of positive affectivity following these rare events (Suh et al., 1996; Watson, 2009). With regard to depression, the frequency of positive life events alone does not appear to modify depression symptoms (Needles & Abramson, 1990). Rather, the relationship between positive events and depression symptomatology is likely modulated by individual differences ranging from cognitive style (Needles & Abramson, 1990) to neurobiological factors (Watson, 2009) that influence the interpretation and/or experience of positive events. Positive affectivity may be a key variable influencing overall well-being, and strong links have been found between positive affectivity and health (Cohen & Pressman, 2006). In the famous nun study, Danner, Snowdon, & Friesen (2001) demonstrated a strong inverse relationship between positive emotional content written in personal autobiographies (e.g., "emotion sentences" coded for affective states such as happiness, love, gratefulness, etc.) and mortality, above and beyond the influence of negative emotional content. Other studies also indicate that positive affectivity is related to lower rates of strokes among the elderly (Ostir et al., 2001). Those reporting a greater tendency to experience positive affect also may have increased resilience to the common cold, even after accounting for the effects associated with negative affect (Cohen, Doyle, Turner, Alper, & Skoner, 2003). Research has shown that those suffering from life-threatening disease with decent prospects of survival (e.g., AIDS, coronary heart disease, early-stage breast cancer) show an association between positive affectivity and improved health outcomes (Pressman & Cohen, 2005). Higher levels of positive affectivity have also been associated with improved sleep quality, more exercise, and lower levels of the stress hormones epinephrine, norepinephrine, and cortisol (Cohen & Pressman, 2006). Additionally, PA has been hypothesized to increase levels of hormones and neurotransmitters, such as oxytocin and growth hormone, as well as endogenous opioids (Pressman & Cohen, 2005). PA also promotes prosocial behavior, empathy, forming closer relationships, and larger social networks (Morelli et al., 2014), which are factors that positively impact overall health outcomes (Cacioppo et al., 2002; Cohen & Pressman, 2006).

3.0.2 Neural Correlates of Positive Affectivity

Although higher levels of positive affectivity have been implicated in promoting well-being, relatively little research has been dedicated to studying associated neural correlates. Advancing the neuroscientific understanding of state and trait positive affect has the potential to facilitate the development of intervention strategies that promote well-being for individuals with psychological and medical disorders. Research has indicated that individuals self-described as happy tend to exhibit more left prefrontal cortical brain activity during resting state, while those endorsing dysphoria show greater right anterior frontal activity (Davidson, 1992; Tomarken & Keener, 1998). Left prefrontal cortex (LPFC) activity is theorized to be related to the mesolimbic dopaminergic system, which is involved in subjective experiences of positive affect and reward-seeking (Burgdorf & Panksepp, 2006; Depue et al., 1994; Depue & Collins, 1999) and marked by an asymmetric concentration of projections in the left frontal region. Related, research has indicated that dopaminergic activity is uniquely associated with positive affectivity (Depue et al., 1994). Research investigating neural responses to affective stimuli using functional magnetic resonance imaging (fMRI) indicates enhanced blood-oxygenation-level-dependent (BOLD) changes predominately in the right occipital cortex (i.e., fusiform cortex, lateral occipital cortex, & medial parietal cortex; Bradley et al., 2003), as well as the amygdala and visual cortex (Sabatinelli et al., 2005) in response to affective (pleasant and unpleasant) compared to neutral images. These BOLD signal changes are correlated with emotional arousal ratings of affective stimuli, irrespective of valence. Indeed, the greatest changes in brain activity are observed for highly arousing stimuli, such as mutilations, erotica, and threat, compared to neutral objects (Bradley et al., 2007). Researchers have posited that individuals who self-report higher levels of positive affectivity may gain more pleasure and exhibit more responsivity to positive stimuli (Gross et al., 1998; Rusting & Larsen, 1997). Previous research investigating the relationship between the personality traits and response to emotional stimuli examined extraversion and neuroticism. Extraversion is defined as a personality trait associated with sociability, warmth, involvement with people, social participation, activity, and contributes to one's enjoyment and satisfaction of life (Costa & McCrae, 1980). Neuroticism is associated with proneness to guilt, anxiety, psychosomatic concerns, worry, and may predispose one to suffer more from one's misfortunes (Costa & McCrae, 1980). Gross and colleagues Gross et al. (1998) observed a positive relationship between extraversion and increases in state positive affect after viewing a positive film clip. No relationship was found between extraversion and changes in state negative affect after viewing a negative film clip (Gross et al., 1998). Thus, those reporting higher positive affectivity may be deriving more pleasure from positive stimuli, which is consistent with reports of more frequent and intense episodes from those endorsing higher levels of positive affectivity (Watson, 2009). These results are also in line with the notion that low levels of extraversion and neuroticism do not appear to reduce unpleasantness of adverse circumstances and diminish joy, respectively (Costa & McCrae, 1980). Overall, this suggests that extraversion and neuroticism may have distinct effects on relatively dissociable affective systems. A study by Canli and colleagues (2001) investigated the relationship between stable personality traits (extraversion and neuroticism) and neural activation in response to positive and negative emotional stimuli. Extraversion scores correlated with brain activation in response to positive (relative to negative) pictures in bilateral cortical (frontal and temporal) and subcortical (e.g., amygdala, dorsal striatum) regions. Neuroticism, on the other hand, correlated with brain activation to negative (relative to positive) images in left temporal and frontal lobes (Canli et al., 2001). No correlations were found between extraversion and neural activation in response to negative (relative to positive) pictures (Canli et al., 2001). This study suggests that personality traits are associated with variability in brain reactivity to emotional stimuli (Canli et al., 2001). Another related study found that left amygdala activation in response to happy faces was positively correlated with extraversion scores (Canli et al., 2002). These data are consistent with behavioral accounts demonstrating an association between positive emotional reactivity and extraversion (Gross & John, 1995). Positive affectivity is highly correlated with extraversion (Costa & McCrae, 1980) and positive is also marked by more intense episodes of positive affect (Watson, 2009). Thus, it can be hypothesized that those with higher levels of positive affectivity may exhibit similar neural affective responsivity.

While neuroscience research has identified some key structures associated with positive affectivity, the neural time course of affective processing associated with positive affectivity has yet to be explored. fMRI methodology has advanced the identification of specific subcortical structures involved in emotion, but its low temporal resolution precludes it from being an effective method of measuring neural time course (Kim et al., 1997). In contrast, electroencephalography (EEG) allows for the analysis of event-related potentials (ERPs) that facilitate assessment of neural responses to affective stimuli with millisecond temporal resolution (Olofsson et al., 2008). This is important considering that the rapid processing of emotional stimuli is characteristic of emotional responsivity (Olofsson et al., 2008) and the perception of threatening/arousing events is enabled by a rapid processing pathway that recruits thalamus and amygdala (LeDoux, 2000). Developing a better understanding of the temporal course of ERPs evoked by affective stimuli will advance knowledge regarding affective processing (Batty & Taylor, 2003; Codispoti et al., 2007; Schupp, Flaisch, et al., 2006; Schupp, Stockburger, et al., 2006; Smith et al., 2004).

Affective neuroscience research utilizing EEG has implicated the late positive potential (LPP), a sustained positive slow wave observed starting as early as 300 ms following stimuli onset, as an established index of evaluative congruency, valence, and arousal in response to visual stimuli (Olofsson et al., 2008). Research has consistently shown that LPP activity over the centroparietal cortex are augmented in the presence of unpleasant and pleasant compared to neutral images (Cuthbert et al., 2000; Keil et al., 2002; Olofsson et al., 2008; Schupp, Markus, et al., 2003). LPP activity is most pronounced for images that are rated as highly arousing (Bradley & Lang, 2007). As such, LPP has been theorized to reflect activation of a brain network engaged in processing affective visual stimuli, including subcortical structures, particularly the amygdala (Bradley & Lang, 2007; Cuthbert et al., 2000; Keil et al., 2002; Olofsson et al., 2008; Schupp, Markus, et al., 2003). Indeed, there is considerable input and output connections connecting the visual cortex to amygdaloid nuclei in primates (Amaral et al., 1992). LPP is theorized to index a visual cortical/amygdala pathway that is involved in evaluating the affective salience of stimuli (Sabatinelli et al., 2007). Several subcortical structures indirectly contribute to the scalp-recorded LPP component, and the extrastriate occipital, inferior temporal, and medial parietal cortex seem to be critical for the observation of LPP (Sabatinelli et al., 2007). LPP may index early processes associated with the salience network (SN) characterized by functional magnetic resonance imaging (fMRI) research. The SN refers to a network of brain regions of the medial wall of the frontal lobe, such as the anterior cingulate cortex and the presupplementary motor area, and the anterior insula (Beckmann et al., 2005; Seeley et al., 2007; Sridharan et al., 2008) and is theorized to be important in assessing importance of internal and external stimuli in order to guide behavior (Seeley et al., 2007). Nodes within the SN independently track feelings of pleasure and displeasure, as well as feelings of arousal in response to feelings of happiness, sadness, and fear (Barrett & Satpute, 2013; Wilson-Mendenhall et al., 2013).

In Cuthbert and colleague's (2000) seminal study of LPP in response to affective stimuli, participants' peripheral physiology and self-reports in response to emotional images were analyzed. One of the main goals of the aforementioned study was to ascertain whether LPPs in response to affective images loaded on the same factors as other established measures of emotional arousal (i.e., affective ratings, facial muscle change, heart rate, & skin conductance). Results indicated LPP activity is enhanced in response to affective images (pleasant and unpleasant) and reduced or absent for neutral stimuli (Cuthbert et al., 2000). Results also indicated a two-factor solution in a principal components analysis, a valence factor and arousal factor. Participant valence ratings, facial muscle change, and heart rate peaks loaded on the valence factor while arousal ratings, average ERP activity (over 400-1000 ms), skin conductance response, interest ratings, and viewing time loaded on a second arousal factor

(Cuthbert et al., 2000). In summary, this study showed that LPP activity are selectively augmented in response to arousing emotional images and these activity positively covary with participant reports of emotional arousal (Cuthbert et al., 2000). This finding of LPP being augmented following pleasant and unpleasant versus unpleasant stimuli has been replicated in a number of other studies (Dillon et al., 2006; Foti & Hajcak, 2008; Hajcak, Moser, et al., 2006; Hajcak, Dunning, Foti, et al., 2007; Hajcak & Nieuwenhuis, 2006; Moser et al., 2006; Schupp et al., 2000; Schupp, Markus, et al., 2003). Much of the aforementioned research has utilized the International Affective Picture System (IAPS; Lang et al., 2008). The IAPS is a set of color pictures that span a range of semantic categories, and valence/arousal ratings derived from a normative sample are provided for each image. The IAPS was developed to provide a standardized stimulus set of emotional images to facilitate the comparison of results across different studies, and enhance replication across research groups (Bradley & Lang, 2007). IAPS images are rated with respect to valence (negative-to-positive) and arousal (low-to-high) on a nine-point visual analogue scale. The IAPS has been used in a number of studies investigating neural correlates of affective processing and emotion regulation (e.g., Foti & Hajcak, 2008; Hajcak & Nieuwenhuis, 2006; Hajcak & Olvet, 2008; Keil et al., 2002; Kim & Hamann, 2007; Moser et al., 2006; Olofsson et al., 2008; Schupp, Markus, et al., 2003). While the IAPS is one of the most used stimuli sets in behavioral research (Kurdi et al., 2017) and it has advanced affective science, many images in the IAPS are subject to copyright restrictions that preclude their use in online research (Kurdi et al., 2017). Further, the copyright agreement that accompanies the stimuli set states that users cannot place any of the images on computer-accessible websites. This may not have been an issue when the IAPS were created in pre-Internet search times, but this poses considerable restraint on increasing reliance on online samples in behavioral research that make data collection from large and diverse samples faster, less costly, and more efficient (Berinsky et al., 2012; Buhrmester et al., 2011; Kraut et al., 2004; Mason & Suri, 2012; Paolacci et al., 2010). Given these advantages, it is hardly surprising that hundreds of online studies are conducted daily, with more and more by the day (Krantz, 2015). Thus, there is an increasing demand for images with standardized valence and arousal ratings for behavioral researchers to use in online contexts. Kurdi, Lazano, and Banaji (2017) heeded this call with the Open Affective Standardized Image Set (OASIS). The OASIS is a collection of 900 high quality images collected from open-access online sources depicting a range of categories (people, animals, objects, & scenes). The OASIS was normed on valence and arousal ratings collected from a diverse sample recruited through Amazon's Mechanical Turk (Kurdi et al., 2017). To the end of fulfilling Dr. Lang and Dr. Bradley's vision of providing researchers experimental control in the selection of stimuli and facilitating comparison of results and replication across different studies, the present study will utilize OASIS stimuli in lieu of the IAPS. Replicating previous research on the neural time course of affective processing of emotional stimuli, it is expected that OASIS stimuli that are rated as more emotionally arousing will be associated with enhanced LPP activity for both positive and negative images compared to neutral images. Furthermore, given that a) positive affectivity is associated with greater frequency and intensity of positive affect, b) LPP is an established index of emotional arousal, and c) past research has indicated that neural responsivity to positive affective stimuli is correlated with extraversion, it is expected that higher self-reported positive affectivity will be associated with larger LPP activity in response to positive OASIS stimuli. ### Emotion Regulation and Savoring Healthy emotion regulation abilities are integral to well-being (Gross, 1998b; Gross & Muñoz, 1995; Koole, 2009; Sapolsky, 2007). Emotion regulation generally refers to individuals' attempts to influence their emotional states (Carl et al., 2013). Broadly, emotion regulation refers to modulation of positive and negative emotional states that are emotionally arousing (Koole, 2009). This also includes attenuating upsetting, or enhancing positive, aspects of a situation (Gross, 1998b). Poor emotion regulation strategies are associated with reduced social functioning, such as avoidance of close relationships, few positive relationships, and disinclination to share emotions with others (Gross, 1998a, 2002; Koole, 2009), as well as lower self-esteem and life satisfaction (Gross, 1998a; Koole, 2009; Ochsner et al., 2002). Poor emotion regulation is also associated with bullying and victimization among youth (Walcott & Landau, 2004), physical ailments such as hypertension and coronary heart disease (Hinton et al., 2009; Jorgensen et al., 1996), exacerbated cortisol reactivity to stressors (Wirtz et al., 2006), and attenuated cognitive functioning (Keenan, 2000; Ochsner et al., 2002). Gross and Levenson (1993) were among the first to empirically study the influence of emotion regulation on physiological responses. This seminal study found differences in heart rate variability, skin conductance, and finger temperature between participants that suppressed emotional behavior (i.e., participants were instructed, “to behave so that someone watching you would not know that you are feeling anything at all.”) in response to neutral and disgusting films and participants that passively watched them. Participants were also asked to indicate their emotional responses to the film by using an inventory consisting of 16 terms (e.g., anger, confusion, happiness, etc.) and rating the greatest amount of each emotion, or affective state, felt during a given film. Despite differences in physiological variability between the suppress and passive watch groups, no differences in self-reported emotion were observed (Gross & Levenson, 1993). This suggests that suppressing negative emotion may result in some reduction of expressive behavior (e.g., facial movement) and physiological arousal, but subjective experience of negatively-valenced stimuli may be no less distressing than if one did not suppress emotion (Gross & Levenson, 1993). A related study found that participants who used an antecedent-focused emotion regulation strategy (reappraisal) while viewing a negatively-valenced film reported less subjective negative emotional response than those instructed to use a response-focused emotion regulation strategy (suppression) or passively watch (Gross, 1998b). Reappraisal and suppression strategies successfully led to decreases in behavioral signs of emotion, measured by coding participants’ behavioral responses (i.e., facial behavioral and upper body movement) in response to the films, but reappraisal was not associated with elevations in physiological responses (i.e., finger pulse activity, finger temperature, skin conductance, & heart rate). Emotional suppression, on the other hand, led to increases in physiological response on several indices (Gross, 1998a). Overall, results suggest that antecedent-focused emotion regulation strategies are a more effective means of experiencing less negative emotional states and, similar to response-focused strategies, successfully decrease behavioral reactions. This, coupled with augmented physiological responses associated with response-focused strategies, may suggest that antecedent-focused emotion regulation is a more effective, or adaptive, means of regulating one's emotions (Gross, 1998a; Gross & John, 2003). These findings also support the association between adverse health consequences and maladaptive emotion regulation strategies, as habitual suppression of emotion may be correlated with chronically elevated physiological arousal (Gross, 1998a; Hinton et al., 2009; Jorgensen et al., 1996). While emotion regulation is often associated with decreasing negative emotion, it also pertains to increasing positive emotion, or savoring. Savoring refers to an awareness of positive experiences and the use of positive emotion regulation strategies to enhance and extend positive feelings that are derived from those experiences (Bryant, 2003, 1989; Bryant et al., 2011; Bryant & Veroff, 2007; J. L. Smith & Bryant, 2017). People initiate savoring responses in reaction to a positive event or affect as a way to maintain, intensify, or prolong the initial positive experience (Bryant & Veroff, 2007). The original conceptual formulation of savoring (Bryant & Veroff, 2007) is predicated on the assumption that people typically initiate savoring responses in reaction to positive events or affect, which people regulate through cognitive or behavioral strategies. Chronically low levels or infrequency of positive affectivity would be expected to reduce savoring responses, which over time would lower self-evaluations of savoring ability. While savoring, one may reminisce about past positive experiences, focus on ongoing positive experiences as they occur, or anticipate the enjoyments of future positive experiences (Bryant & Veroff, 2007). Regardless of the temporal focus, savoring processes regulate positive emotions in the present moment. Savoring is associated with a number of positive outcomes. Research has indicated that those with a greater capacity to savor possess increased life satisfaction, affective intensity, and self-esteem (Bryant et al., 2011). Past research has also revealed that savoring is related to present happiness, total percent of time feeling happy versus sad, extraversion, optimism, and self-esteem. Furthermore, savoring is negatively associated with depression, neuroticism, and hopelessness (Bryant, 2003; Eisner et al., 2009; Hou et al., 2016; Ramsey & Gentzler, 2014; Smith & Hollinger-Smith, 2015). A separate study found that savoring the moment is related to higher life satisfaction, subjective happiness, and overall higher levels of positive affect (Hurley & Kwon, 2012). Other research has similarly revealed that savoring was strongly related to higher levels of present happiness, higher self-esteem, and lower reported levels of depression (Bryant, 2003). Furthermore, increased savoring capacity is associated with pain resilience (Thong et al., 2016). In sum, savoring may be a key mechanism in deriving vitality from our lives. Savoring may have the potential to improve treatment of depression. Common treatments for depression include cognitive behavioral therapy (CBT), antidepressant medication, or a combination of them (Price & Drevets, 2010). Regrettably, 45-65% of those with depression undergoing CBT do not achieve remission (DeRubeis et al., 2005). This leaves considerable room for improvement that may be fulfilled by integrating savoring into treatment. Indeed, greater savoring beliefs are correlated with lower levels of depressive symptoms (Bryant, 2003; Eisner et al., 2009; Hou et al., 2016; Ramsey & Gentzler, 2014; Smith & Hollinger-Smith, 2015). A more thorough understanding of the mechanisms of savoring, may pave the way for improving treatments for depression. Intervention studies aimed at enhancing savoring capacity show that enriching any three of the three temporal domains of the savoring (reminiscing, savoring the moment, or anticipating) is associated with greater life satisfaction, increased frequency and intensity of positive affect, and decreased negative affect (for a review, see Smith et al., 2014). Given that savoring is strongly associated with a number of positive outcomes and may improve current treatment methods for mental illness, further research is needed, particularly regarding its neural correlates. ### Neural Correlates of Emotion Regulation A substantial body of research has been dedicated to emotion regulation in an effort to understand its neural correlates. fMRI research has identified specific brain structures implicated in emotion regulation processes. A general pattern of findings from this research is an association between reappraisal of negative emotional stimuli and 1) activation of the dorsal anterior cingulate cortex (ACC) and prefrontal cortex (PFC) systems that are implicated in the selection and use of reappraisal strategies and 2) increases, decreases, or maintenance of activity in the amygdala or insula that is in accordance with the goal of reappraisal (Beauregard et al., 2001; Lévesque et al., 2003; Ochsner et al., 2004, 2002; Phan et al., 2005; Schaefer et al., 2002). For example, Ochsner et al. (2004) analyzed brain structures correlated with reappraisal of negative images (to increase or decrease emotional significance of the image) via fMRI. Both up and down regulation strategies were associated with increased PFC and ACC activity, while amygdala activity increased or decreased in line with the regulatory goal (Ochsner et al., 2004). Another study conducted by Beauregard and colleagues (2001) similarly found that volitional inhibition of emotional arousal in response to erotic stimuli was associated with increased PFC and ACC activity and decreased amygdala activation compared to passively watching viewing stimuli. Neuroscience research on emotion regulation has almost exclusively focused on negative emotion, with relatively little attention paid to savoring. There are numerous benefits associated with the capacity to increase positive emotion (Bryant, 2003; Eisner et al., 2009; Hou et al., 2016; Ramsey & Gentzler, 2014; Smith et al., 2014; Smith & Hollinger-Smith, 2015). A more refined understanding of its neural correlates will be instrumental in devising neuroscience-informed clinical interventions aimed at increased savoring capacity. One of the few studies that probed the neural correlates of positive emotion regulation examined fMRI BOLD response while participants increased and decreased emotional intensity in response to positive and negative images (Kim & Hamann, 2007). Consistent with previous research, results of the study indicated that volitional emotion regulation modulated amygdala activity in both regulation conditions for positive and negative stimuli compared to watch conditions. More specifically, increasing emotional intensity showed a positive relationship in activation between the amygdala and structures (e.g., ACC and PFC) implicated in cognitive control. On the other hand, decreasing emotional intensity changed the direction of the relationship, with greater activation of cognitive control regions being related to attenuated amygdala activity (Kim & Hamann, 2007). The aforementioned studies have focused primarily on identifying specific brain regions involved in emotion regulation, but very little is known about the processing stages, or neural time course, of emotion regulation. The manner in which emotional responses unfold over time are a function of regulatory goals and attentional allocation (Hajcak, Dunning, Foti, et al., 2007). fMRI gives insight to this process in the form of a static portrait. However, tracking how neural activation unfolds and changes over time is essential in better characterizing the process of emotion regulation and delineating which structures activate concomitantly with reactive and regulatory processes (Hajcak, Dunning, Foti, et al., 2007). To this end, EEG is an ideal method to use since its measures near-instantaneous activity of cortical activation (Hajcak, Dunning, Foti, et al., 2007). As previously mentioned, LPP is theorized to index a visual cortical/amygdala pathway that is involved in evaluating the affective salience of stimuli (Sabatinelli et al., 2005). Thus, it could be reasonably hypothesized that the aforementioned fMRI research would translate to modulation of LPP signals dependent on the appraisal of emotional stimuli. Research has supported this claim. One study conducted by Foti & Hajcak (2008) examined changes in LPP activity when negative images were preceded by more or less negative descriptions. When unpleasant pictures were explained more neutrally, resulting LPP activity were reduced compared to unpleasant pictures that were described negatively (Foti & Hajcak, 2008). In a similar vein, one study compared LPP activity in affective and non-affective appraisal conditions of emotional stimuli. In the non-affective condition, participants were instructed to report the number of people were in each image. During affective conditions, participants rated images as pleasant or unpleasant. Compared to the affective condition, LPP was reliably reduced in the non-affective condition for positive and negative stimuli (Hajcak, Moser, et al., 2006). Collectively, these studies illustrate that LPP is not only sensitive to the emotional content of stimuli, but also how the stimuli are appraised. These aforementioned studies have indeed illustrated that LPP activity can be modulated, but what of more deliberate regulation strategies akin to savoring? Moser et al. (2006) asked participants to deliberately suppress or enhance emotional intensity in response to high arousing negative and neutral images. A passive viewing, or "watch" condition was also included. Participants' LPP activity were significantly smaller when suppressing emotional response to negative images compared to passively watching them. A notable finding of this study was that there were no observed differences in LPP between passive watch and enhance conditions. The authors attribute this to a number of factors, one of which was the utilization of only unpleasant images. Using pleasant images, they argue, may produce an augmented LPP in the enhance condition. In response, Krompinger et al. (2008) analyzed LPP signals in response to increasing and decreasing emotional responses to, as well as passively watching, positive images. Results indicated increased LPP signals in response to passively watching positive stimuli compared to neutral stimuli. Furthermore, LPP signals were attenuated when participants were instructed to suppress emotional response vs. passively watch. However, no significant differences were found for the enhance condition (Krompinger et al., 2008). The authors noted several limitations of this experiment, such as a relatively short stimulus duration compared to other studies (500 vs. 2000-6000 ms) that successfully captured emotional enhancement of affective stimuli (Ochsner et al., 2004). Furthermore, this study did not collect self-report trait data. Considering that past research has found correlations between personality trait measures and neural activation in response to emotional stimuli (Canli et al., 2001, 2002), a trait measure specifically measuring the regulation of positive emotion (i.e., savoring beliefs) may explain additional variance that is not being accounted for. Given the inconsistent findings regarding the enhancement of emotional arousal in response to positive stimuli, further research is warranted. Moser and colleagues (2006) make the important observation that LPP is affected by intentional regulation strategies and that, "...LPP may also be a viable dependent measure of the interaction between cognitive and affective processing." Savoring is a type of emotion regulation, and thus may be related to structures implicated in metacognition (e.g., ACC and PFC). Since a) LPP may be an indicator of this cognitive-affective interaction, b) LPP is an index of emotional arousal, and c) savoring is an emotion regulation strategy associated with increased emotional arousal in response to positive affect/events, it is hypothesized that the relationship between increasing emotional arousal in response to positive images and LPP will be dependent on one's capacity to savor. More specifically, LPP may be modulated when increasing emotional intensity in response to positive stimuli and that this relationship is expected to be moderated by savoring capacity. ### The present study Past research utilizing EEG has indicated that higher arousal in response to stimuli yields augmented LPP signals (Cuthbert et al., 2000; Hajcak & Nieuwenhuis, 2006; Schupp et al., 2000; Thiruchselvam et al., 2011; Tritt et al., 2016). Increasing emotional intensity results in enhanced amygdala activity and structures related to cognitive control (Kim & Hamann, 2007). fMRI research has demonstrated that personality trait ratings (extraversion and neuroticism) correlate with neural responsivity to affective stimuli (Canli et al., 2001, 2002). Given that positive affectivity and extraversion are associated with more positive emotional arousal, it was hypothesized that the relationship between LPP signals and viewing positive stimuli will be dependent upon levels of positive affectivity. LPP is theorized to be indicative of an interaction between amygdala and cognitive control structures (Moser et al., 2006). Furthermore, savoring capacity is positively associated with affect intensity and is indicative of one's ability to bolster positive emotion (Bryant, 2003). Thus, savoring may be related to activation of neural structures associated with cognitive control. Therefore, higher self-report ratings of one's capacity to savor were expected to moderate the relationship between LPP signals and increased emotional intensity in response to positive stimuli. The primary aims and hypotheses of the present study were as follows: Study Hypotheses. The present study had two primary objectives. The first objective of the proposed study was to investigate the relationship between highly arousing affective vs. neutral OASIS stimuli and parietal cortical activity (LPP). It was hypothesized that a) highly arousing positive vs. neutral OASIS stimuli would be associated with greater LPP activity (Hypothesis 1a; Figure 1) and b) highly arousing negative vs. neutral OASIS stimuli would be associated with greater LPP activity (Hypothesis 1b; Figure 1). The second objective was to examine the relationship between personality traits pertaining to positive emotion and LPP activity. It was predicted that a) positive affectivity would moderate the relationship between watching positive images and LPP activity (Hypothesis 2a; Figure 2) and b) savoring capacity would moderate the relationship between increasing emotional intensity in response to positive images and LPP activity (Hypothesis 2b; Figure 3). ### Exploratory analyses The aforementioned aims and hypotheses were a priori and preregistered (link: https://osf.io/p5ba9/). Post hoc exploratory analyses were also conducted. In addition to the LPP, the early posterior negativity (EPN) has also been found to be modulated by emotional valence of stimuli (Schupp et al., 2012). The EPN has been observed as a relative negative difference for stimuli as emotionally arousing/valenced compared to neutral stimuli in the 200 - 300 ms window over occipital parietal sites with corresponding fronto-central positivity (Olofsson et al., 2008; Schupp, Junghöfer, et al., 2003; Schupp et al., 2000). EPN has been observed across a variety of different tasks, inter-stimulus intervals (ISI), and stimulus presentation durations (Olofsson et al., 2008), leading researchers to surmise that the EPN reflects relatively automatic processes that is observed even when processing resources are limited due to rapid presentation rates (Junghöfer et al., 2001; Schupp, Junghöfer, et al., 2003; Schupp, Markus, et al., 2003). This sensitivity may index rapid affective amygdala processing of emotionally salient information (LeDoux, 1995; Morris et al., 1998) and is also theorized to indicate "natural selective attention" where evaluation of image features is contingent upon affectively arousing perceptual characteristics for additional processing (Dolcos & Cabeza, 2002; Schupp et al., 2004). Thus, it is hypothesized that highly arousing positive and negative OASIS images will elicit greater EPN compared to neutral OASIS images. Some research has indicated that EPN is sensitive to emotion regulation. Herbert and colleagues (2013) found that EPN signals were significantly attenuated during active downregulation of emotional intensity in response to pictures of fearful faces. Such effects were not found for downregulation of emotional intensity in response to happy faces (Herbert et al., 2013). One study analyzed EPN differences among participants with low and high trait anxiety in an implicit emotion regulation task in response to pictures of faces (Liu et al., 2018). The study found that implicit emotion regulation processing led to more significant decreases in behavioral negative emotion experience scores, and that these decreases in negative emotion experience scores were associated with enlarged EPN (Liu et al., 2018). Lastly, these enlargements were observed for participants with low trait anxiety but not high grait anxiety, suggesting deficits in implicit emotion regulation among those with anxiety (Liu et al., 2018).

Discuss implicit ER in Luo article and how EPN may index implicit ER - reduced EPN amplitude in individuals with high trait anxiety. ### Method #### Participants 54 participants were recruited for the study, 48 of which were included in analyses (n = 27 women, n = 2 non-binary). Six participants were excluded due to insufficient number of valid EEG task trials. Participants ranged in age from 18-29 (M = 19.78 years, SD = 2.03). The sample was 69.6% Caucasian, 17.4% Asian, 2.1% Black or African American, and 8.7% Biracial (2.1% declined to answer); 10.9% reported that they were Hispanic/Latino and 89.1% were not Hispanic/Latino. The study was approved by the Institutional Review Board and informed consent was provided to all participants prior to beginning the experiment.

3.0.2.1 Materials and Procedure

Participants were asked to complete the trait Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) to assess for positive affectivity (α = .86). At the beginning and end of the experiment, participants were also asked to complete the state PANAS in order to assess state affect changes over the course of the experiment (α = .86; Watson et al., 1988). Participants also completed the Savoring Beliefs Inventory (SBI; Bryant, 2009). The SBI measures the perception of one's ability to feel pleasure through anticipating positive outcomes (α = .87), savoring positive moments (α = .83), and reminiscing about past positive events (α = .86; Bryant, 2009). Only the momentary savoring subscale was used in the following analyses, as this temporal domain was most relevant to the present hypotheses and experimental paradigm. 64-channel high-density electroencephalography (EEG) data were recorded while participants viewed seven blocks of 40 images (280 total trials). The study used 120 different Open Affective Standardized Image Set (OASIS) images (Kurdi et al., 2017). 40 of the images were positive, 40 were neutral, and 40 were negative. Previous research has shown that 40 trials is sufficient to evoke a reliable late positive potential (LPP) component (Foti & Hajcak, 2008; Hajcak, Moser, et al., 2006; Hajcak & Nieuwenhuis, 2006; Hajcak & Olvet, 2008). The mean normative valence ratings (on a scale of one to seven) were 5.71, 4.09, and 2.18 for positive, neutral, and negative pictures, respectively. The mean normative arousal ratings (on a scale of one to seven) were 4.46, 1.99, and 4.52, for positive, neutral, and negative pictures, respectively. Though previous studies have used the IAPS, theses means are similar to those reported in other LPP studies (Cuthbert et al., 2000; Foti et al., 2009; Hajcak & Nieuwenhuis, 2006; Keil et al., 2002; Schupp, Junghöfer, et al., 2003).

Each block represented an experimental regulation condition: increase (positive/negative), decrease (positive/negative), and watch (positive/negative/neutral). During the increase condition, participants were instructed to appraise the picture in a way that will intensify the emotion that is elicited by looking at it. During the decrease condition, participants were asked to reduce the intensity of the emotion that is elicited by looking at the picture. When prompted to watch, participants were asked to view the picture as they would naturally. The passive "watch" blocks served as baseline conditions for LPP component analyses (Hajcak & Nieuwenhuis, 2006). A block design was selected for the proposed study because valenced images outnumber the neutral images two-to-one. The relatively rare neutral stimuli may produce a P3 if intermixed with valenced stimuli in the same block (Schupp et al., 2000).Additionally, LPP signal is increased for stimuli that are percieved as incongruent within a given affective context. Thus, a neutral stimulus displayed in a series of emotional stimuli would likely evoke an enahnced LPP activity, thus decreasing effect size (Schupp et al., 2000). Further, a block design paradigm may better emulate one's natural environment. Stimuli of congruent valence are typically encountered in clusters rather than isolation (Schupp et al., 2012). Research comparing intermixed and block designs for LPP and EPN have shown comparable findings between the two approaches (Pastor et al., 2008; Schupp et al., 2012).

First, participants completed three practice trials that consisted of 10 not used during the actual task (Hajcak & Nieuwenhuis, 2006). Participants were instructed to increase or decrease emotional arousal in response to a mixture of positive and negative images, respectively. Participants were also asked to watch a third practice trial comprised of positive, negative, and neutral images. Stimuli were presented in random order. Prior to each practice trial, participants were provided with instructions on how to regulate (increase/decrease) their affective response to the stimuli, or to simply view the stimuli (Moser et al., 2006). Participants were shown which regulation strategy to engage in (increase, decrease, or watch) at the start of each experimental block. Once the participant was ready, an OASIS stimulus appeared for 2000 ms (Foti et al., 2009; Hajcak & Olvet, 2008). Following stimulus offset, a blank screen appeared for 500 ms followed by a fixation cross for 1500 ms (± 250 ms) for a total ISI of 1750 - 2250 ms. This interval is identical to other studies utilizing the IAPS and investigating LPP (Dunning & Hajcak, 2009; Hajcak et al., 2009). Stimuli within each block were presented in random order. Each block was separated by a break and presented in random order. After each experimental block, valence and arousal ratings were collected using a seven-point likert scale and the same instructions used in Kurdi, Lozano, and Banaji's (2017) norming study of the OASIS stimuli set. Furthermore, difficulty ratings on a seven-point likert scale were also obtained.

3.0.2.2 Apparatus and Physiological Recording

Scalp EEG was measured while participants completed an emotion regulation task. Participants were seated in a comfortable chair, approximately 24 inches from a 24-inch LCD monitor in a quiet, dimly lit room. Participants were monitored by a task administrator in a nearby room and received task instructions by intercom. EEG data were recorded using a Biosemi Active2 EEG system. A custom-designed Falk Minow 64-channel cap with equidistantly spaced BioSemi active Ag and AgCl electrodes was used for data collection. CMS/DRL was placed near the vertex, and two electrodes were located on the mastoid bones. After placement of the electrode cap, electrode positions were digitized. An additional electrode was placed on the inferior edge of the orbit of each eye to monitor vertical eye movements; nearby electrodes in the cap (lateral to each eye) monitored horizontal eye movements. Data was recorded with a band pass of 0 – 104 Hz at a sampling rate of 512 Hz. The following EEG data processing steps were implemented in Brain Electrical Source Analysis software (BESA; Scherg & Berg, 1990). EEG data were re-referenced to the average activity of the mastoid electrodes (Hajcak, Moser, et al., 2006; Hajcak & Nieuwenhuis, 2006) and digitally filtered with a half-power amplifier bandpass at 0.01–30 Hz, with a cutoff attenuation of 12 dB/octave. Muscle (e.g., eye blink, eye movement) and other artifacts were removed and/or corrected via implementing automatic algorithms in BESA. Stimulus-locked averages were calculated to ascertain LPP. The data were baseline-adjusted by subtracting the average activity for 200 milliseconds (Hajcak et al., 2006) before stimulus onset. LPP activity was calculated as the average activity in the 300 – 800 ms window at Pz, P1, P2 and CPz electrode sites. The scoring window and sites were selected based upon the existing literature as well as visual inspection of the data to determine where LPP activity was maximal in the present sample. The selected scoring window and electrode sites were similar to other studies investigating LPP in similar contexts (Hajcak et al., 2006; Hajcak & Nieuwenhuis, 2006; Moser et al., 2006). The experiment was computer-administered, using E-Prime 2.0 software (Schneider et al., 2002) in order to manipulate the timing and presentation of stimuli. All stimuli were presented in color and occupied the entirety of the 21-inch monitor. The viewing distance was approximately 24 in. and occupied 25°of the vertical visual angle and 30° horizontally (Cuthbert et al., 2000; Hajcak & Nieuwenhuis, 2006).

3.0.3 Results

The first objective of the proposed study was to investigate the relationship between highly arousing affective vs. neutral stimuli from the OASIS and parietal cortical activity (LPP). Data below a skewness statistic of 1.0 were considered normally distributed. No variables of interest violated this threshold. Participants without valid EEG data were excluded from the following analyses ($n = 6$). No other data were missing from variables of interest. All analyses were run in R version 3.5.0 (R Core Team, 2018). Multilevel modeling (MLM) analyses were conducted using the lme4 package (Bates et al., 2015). Means and standard deviations of LPP activity and participant ratings (arousal, valence, and difficulty) were calculated for each of the experimental blocks (see Table 1). In order to evaluate whether the experimental blocks varied on arousal and valence, a repeated measures analysis of variance yielded significant variation among image blocks for arousal ($F(6, 270) = 25.02$, $p < .001$) and valence ($F(6, 270) = 80.43$, $p < .001$) ratings. Tukey's HSD test was used to calculate comparisons across all blocks for arousal (see Table 2) and valence (see Table 3) ratings using the psycho package (Makowski, 2018). Pearson correlations were run among psychological and physiological variables across the sample. Significant correlations were found between several variables (see Table 4). Means and standard deviations of between-subjects variables (savoring the moment, trait positive affect, and state positive affect) were also derived (see Table 4).

Before testing primary hypotheses, a null model was run to assess whether the grouping variable (participant) differed on the outcome variable (parietal cortical activity) and to estimate the degree of nonindependence in the sample. An intraclass-correlation indicated that that 56% of the total variance in LPP activity is accounted for by differences between participants' average LPP activity. This necessitates an analytical technique, such as MLM, that accounts for non-independence. Semi-partial Rˆ2 was calculated for model parameters to estimate relative variance explained by each predictor (Edwards et al., 2008; Tritt et al., 2016). #### Hypotheses 1a & 1b. MLM with variance components covariance matrices to estimate random intercepts and slopes for each participant was used to test whether increased LPP activity is associated with passively viewing highly arousing affective compared to neutral OASIS stimuli. Dummy-coded block (within subjects: neutral watch block as reference level) and mean- centered valence (within subjects) variables were included in the omnibus model to predict LPP activity while accounting for the variance attributed to the how positive or negative participants rated each block. A main effect of block type upon LPP activity was found (positive watch; $b = 1.38$, $SE = .39$, $t(244.96) = 3.52$, $p < .001$, $R^2 = .03$; negative watch; $b = 2.12$, $SE = .42$, $t(249.05) = 5.10$, $p < .001$, $R^2 = .06$). These findings indicate that passively viewing affective (positive and negative) compared to neutral OASIS images is associated with enhanced LPP activity (see Figure 4). #### Hypothesis 2a The second objective was to examine the relationship between personality traits pertaining to positive emotion (i.e., positive affectivity and savoring capacity) and parietal cortical activity. MLM with variance components covariance matrices to estimate random intercepts and slopes for each participant was used to test if the relationship between LPP activity and passively viewing positive images versus neutral images varied as a function of trait positive affect. Dummy-coded block (within subjects: neutral watch block as reference level), mean-centered difficulty rating (within subjects), mean-centered trait positive affect (between subjects), and mean-centered state positive affect (between subjects) variables were included in the omnibus model. An interaction term between block and trait positive affect variables was also added to probe for a conditional relationship between block and LPP activity as a function of trait positive affect while accounting for the variance attributed to the how difficult participants rated each block and their state positive affect. Results did not indicate a significant interaction between viewing condition and positive affectivity in predicting LPP activity ($b = 0.03$, $SE = .06$, $t(262.81) = 0.50$, $p = .620$, $R^2 < .01$). #### Hypothesis 2b MLM with variance components covariance matrices to estimate random intercepts and slopes for each participant was used to test if the relationship between parietal cortical activity and increasing emotional intensity in response to positive images versus passively watching positive images (see Figure 5) varied as a function of momentary savoring capacity. Dummy-coded block (within subjects: positive watch block as reference level), mean- centered difficulty rating (within subjects), mean-centered savoring capacity (between subjects), and mean-centered trait positive affect (between subjects) variables were included in the omnibus model. An interaction term between the block and savoring capacity variables was added to probe for a conditional relationship between block and LPP activity as a function of momentary savoring capacity while accounting for the variance attributed to the how difficult participants rated each block and their trait positive affect. Results did not indicate a significant interaction between viewing condition and savoring capacity in predicting LPP activity ($b = 0.30$, $SE = .39$, $t(262.79) = 0.76$, $p = .445$, $R^2 < .01$).

3.0.4 DISCUSSION

The present study sought to explore the OASIS as an alternative to the IAPS in psychophysiological research as well the role of personality traits in neural affective processing. This research will help introduce more up-to-date and open access materials in affective neuroscience research and devise neuroscience-informed clinical interventions to enhance positive emotion. We found that, similar to the IAPS, highly arousing positive and negative OASIS stimuli elicited augmented LPP activity. Furthermore, positive affectivity and capacity to savor the moment did not influence the relationship between passively viewing and increasing emotional intensity in response to positive images, respectively. Results suggest that highly arousing positive and negative images are correlated with enhanced parietal cortical activity. This is a common finding in research investigating the neural time course of affective processing with the IAPS (Cuthbert et al., 2000; Hajcak et al., 2009; Hajcak, Dunning, & Foti, 2007; Krompinger et al., 2008; Moser et al., 2006; Schupp et al., 2000; Tritt et al., 2016). Participant rating scales in the present study indicated that passively viewing positive and negative image blocks were associated with more arousal when compared to neutral images. Passively watching negative images was associated with higher arousal ratings when compared to positive images. Passively viewing negative images was associated with valence scores that were significantly lower than neutral images, yet the difference between positive and neutral images was not significant. This suggests that negatively-valenced stimuli may have more profound effects on state manipulations of emotion than positively-valenced stimuli. Notably, these behavioral ratings did not correlate with LPP activity. This may be attributed to the fact that participant ratings likely reflect state manipulations at the end of each block while LPP may reflect arousal and/or valence in response to each image. Overall, these findings lend support to the OASIS image set being used in subsequent psychophysiological studies investigating the neural time course of affective processing. The OASIS also has several advantages over the IAPS. More specifically, it is up-to-date, spans a number of semantic categories, and is open access (Kurdi et al., 2017).

Evidence of conditional relationships between regulating one's emotion in response to affective images and LPP activity as a function of personality traits pertaining to positive emotion was not found. This is a departure from earlier fMRI research investigating correlations between neural activation in response to pleasant stimuli/happy faces and the personality trait of extraversion (Canli et al., 2001, 2002). This discrepancy could be due to different methods. Canli et al. (2001, 2002) utilized fMRI and presented five blocks of four pictures that were presented for 7.5 seconds each while the present study used EEG and utilized seven blocks of 40 image blocks that were presented for two seconds each. fMRI does not have the temporal resolution necessary to analyze timing in the 0 – 3000 ms time window as the present study did. Thus, it is possible that different components were being analyzed in Canli et al. (2001, 2002) and the present study. Furthermore, Canli et al. (2001) limited their sample to only women on the grounds that, "...they are more likely to report intense emotional experiences (Shields, 1991) and because they show more physiological reactivity in concordance with valence judgments than men (Lang, Greenwald, Bradley, & Hamm, 1993)." In contrast, the present study recruited participants regardless of gender in order produce more generalizable findings. Additionally, different statistical analyses were utilized in the present study compared to those reported in Canli et al. (2002, 2003). Though the language used in Canli et al. (2003) suggests a moderation analysis: "...given that amygdala activation to positive emotional scenes varies as a function of this trait..." (p. 1), closer inspection indicates that correlations between z scores for voxels in fMRI slices and personality traits were reported. This technique necessitates multiple statistical tests, inflating type-I error, and is unable to account for variance attributed to other variables. True moderation analyses, as performed in the present study, are tested in a single regression model that allows one to statistically control for effects of other variables. There are several other noteworthy aspects of the present study. Psychology is in the midst of a "replicability crisis," suggesting that a majority of published findings in the field may be false (Baker, 2015). This is compounded by instances of scientific misconduct (Stroebe et al., 2012), unwillingness to share data for re-analyses (Wicherts et al., 2006), and questionable statistical practices (Simmons et al., 2011). It is incumbent upon psychological researchers to resolve these problems. To this end, hypotheses of the present study were preregistered with the Center for Open Science (link: https://osf.io/p5ba9/). Furthermore, all data and R code used for data management, analyses, and ERP visualizations are publicly available so that others may independently replicate reported results. This study is also notable for the analytical technique utilized to test main hypotheses (MLM). MLM improves upon the most commonly used technique in ERP research, repeated measures analysis of variance, in several ways: 1) MLM accepts categorical and continuous predictors, 2) researchers can use partial data in MLM analyses, and 3) more complex models can be specified using MLM. Lastly, previous studies utilizing affective stimuli and EEG utilized an experimental design that randomly presents images of intermixed valence (positive, negative, and neutral). LPP is sensitive to intrinsic affective properties of stimuli picture and the local affective context in which the picture is presented (Schupp et al., 2000). There may be overlap between neural responsivity to incongruency and psychophysiological components of interest related to a behavioral task (e.g., increasing or decreasing emotional intensity) in these randomized designs. This may introduce extraneous variance not germane to the question at hand. The present study rectifies this methodological issue by utilizing a block design where no images were presented in an affectively incongruent context. The present study contributes to the field beyond its findings through its transparency as well as its methodological and statistical rigor. Despite the strengths and novelty of this experiment, there are limitations. The psychophysiological data collected are cross-sectional and causation cannot be inferred. While we have done our best to adhere to open science principles, software used for EEG reduction is closed source (BESA; Scherg & Berg, 1990). While we are unable to share materials or code that can replicate our data reduction analyses, we have provided step-by-step instructions that were used for data reduction. Lastly, the present study's exclusionary criteria (only recruited participants who were right-handed, not color-blind, and learned English as a first language) and reliance on a convenience sample mostly comprised of Caucasian college students limits ability to generalize findings to a more diverse population. Future research should investigate the neural correlates of positive emotion regulation in more diverse samples. Much research on this topic (the present study included) relies on convenience samples (e.g., Hajcak & Nieuwenhuis, 2006; Kim & Hamann, 2007; Moser et al., 2006). Research indicates that past adverse experiences may contribute to one's capacity to savor present events (Croft et al., 2014). An interesting future line of inquiry may examine if past experiences predict certain patterns of neural activity in response to emotional stimuli. Additionally, research indicates that psychopathology influences emotion regulation and salience of emotional stimuli (Ehring et al., 2010; Gotlib et al., 2004; Hamilton & Gotlib, 2008; Joormann & Gotlib, 2010; Joormann & Vanderlind, 2014). Future research should investigate how depression and anxiety influence neural activity in response to passively viewing and regulating one's emotion in response to affective stimuli. It may be that the LPP is not capturing the mechanism most relevant to savoring or positive affectivity. Thus, future research should consider utilizing different EEG methods. For example, source analysis is able to identify subcortical neural source generators of EEG activity. Considering that savoring is a form of emotion regulation, it may be related to structures implicated in metacognition, such as the ACC. Another method to consider is time-frequency analysis, which is able to simultaneously measure signals in time and frequency domains. Frontal EEG alpha band frequency asymmetry has been observed at rest in those with depression (Gotlib, 1998; Keune et al., 2013; Stewart et al., 2011; Thibodeau et al., 2006), and research has also shown correlations between reductions of frontal alpha band EEG frequency and decreased depression symptomatology (Zotev et al., 2016). Considering that low positive affectivity is theorized to be a specific risk factor for depression (Clark & Watson, 1991; Kendall et al., 2015; Lewinsohn & Graf, 1973; Raes et al., 2012; Watson, Weber, et al., 1995; Watson, Clark, et al., 1995) and related to exacerbated depressive symptomatology (Clark & Watson, 1991; Davidson, 1998a; Watson et al., 2015), it may be associated with less left frontal EEG alpha-band frequency. This is one of the first studies to examine the neural time course of affective processing using the OASIS. Results indicate that it is an appropriate replacement for the IAPS. Future researchers would be wise to utilize the OASIS in order to facilitate comparison of results across studies and capitalize on its high quality, open access, and up-to-date stimuli. Results of the present study did not support the hypotheses that positive affectivity and capacity to savor the moment alter the relationship between passively viewing and increasing emotional intensity in response to positive images, respectively. However, future aims have been identified based on these findings, such as examining the role that past experiences/psychopathology play in neural affective processing, recruiting a more diverse sample, and utilizing different EEG methods (e.g., source analysis, time frequency analysis) to study how the neural time course of affective processing interacts with positive affectivity and savoring capacity. The study is limited by its use of cross-sectional data, precluding causal inference, and a sample predominately comprised of Caucasian college students, which limits generalizability of findings. Regardless of these limitations, the present study sets standards for open science practice, statistical analyses, and methods for future research in affective neuroscience. The present study brings attention to the often-neglected study of positive emotion and its neural correlates. Past research on affective processing has overwhelmingly focused on negative emotion. This work is useful for mitigating the effects of unpleasant emotion but may not benefit individuals in need of bolstered levels ofpositive emotion. Uncovering the biological implementations of positive emotion will be crucial for developing therapeutic and pharmacological interventions for those suffering from psychological and physiological ailments. It may also bring us a step closer to harnessing the mechanisms of well-being.

CHAPTER 4

CONCLUSIONS

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