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The Role of Mindfulness in the Regulation of Behavior Among Those Prone to Negative Urgency

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THE ROLE OF MINDFULNESS IN THE REGULATION OF BEHAVIOR AMONG THOSE PRONE TO NEGATIVE URGENCY

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University

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Abstract

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Negative emotions can be challenging to regulate, and for some individuals can lead to failures of behavior regulation. The present study is an initial effort to explore the role that mindfulness may play in fostering effective behavior regulation among those prone to high negative urgency (NU). Eighty undergraduate students were recruited based on their high or low scores of NU. First, participants completed a self-report measure of mindfulness (Mindful Attention Awareness Scale; MAAS), an Emotional Go/No Go task in an fMRI scanner, and then reported alcohol consumption. Results showed that those with high in NU had low levels of mindfulness compared to those low in NU. Mindfulness predicted substance use at the one-month follow-up after controlling for the predictive roles of NU and gender. Further exploration of the underlying neural mechanisms of mindfulness is needed to better understand its impact on emotion- and self-regulatory processes, especially during difficult emotional experience.

The Role of Mindfulness in the Regulation of Behavior among those Prone to Negative Urgency

Emotions inform how we make decisions in both intrapersonal and interpersonal contexts. Yet as much as emotional responses to what we encounter can be helpful, they can also be maladaptive, detrimentally impacting our relationships as well as our own well-being. People often attempt to use emotion regulatory and self-regulatory strategies to inhibit maladaptive behavior and to maintain healthy relationships and well-being. Yet the regulation of behavior can be challenging when experienced emotions are “negative,” and failures to adaptively regulate such emotions can lead to maladaptive self-regulation of behavior. For instance, people may abuse substances in order to avoid negative feelings (Otto, O’Cleirigh, & Pollack, 2007), which in turn may have detrimental inter- and intra-personal consequences.

Efforts have been made to understand what personality characteristics and intervention models can maintain healthy behavior regulation in the face of difficult emotions (Cameron & Jago, 2008; Thompson, 1994; John & Gross, 2004). The present research was designed to further examine this issue by asking whether a quality of attention termed *mindfulness* can protect individuals against maladaptive self-regulation when facing negative emotions. A focus on mindfulness has several advantages for this purpose. Since mindfulness concerns how we attend to what we encounter, it has the potential to alter how we relate to emotions before they become strong and more difficult to regulate (Sheppes & Gross, 2011). Second, there is indication that mindfulness can enhance healthy emotion regulation (Arch & Landy, 2015) and behavior regulation (Brewer et al., 2011; Brewer et al., 2009; Chatzisarantis & Hagger, 2007). Finally mindfulness appears to be very trainable (Zeidan et al., 2010; Quickel, Johnson, & David, 2014), offering the potential to boost regulatory capacities.

The Neuroscience of Emotion- and Behavior-regulatory Processes

Emotion- and self-regulatory processes can unfold rapidly and may not be easily reportable when experienced. For these reasons considerable work has been devoted to understanding these processes at the neural level, largely relying upon brain imaging techniques like functional Magnetic Resonance Imaging (fMRI) and electroencephalography (EEG). Substantial evidence suggests that subcortical regions in the brain such as the amygdala are implicated in negative emotional reactions to provocative stimuli. For instance an fMRI study found that when participants were simply told to attend as normal to aversive visual stimuli, greater amygdala activation was associated with increased emotional responding compared to conditions wherein participants were instructed to "reappraise" (reinterpret the stimuli as neutral), suggesting that amygdala plays a critical role in processing negative emotional stimuli (Ochsner, Bunge, Gross, & Gabrieli, 2002). Consistent with this human work on the amygdala, early work with animal models suggests that damage to the limbic system (wherein the amygdala is housed) resulted in placid responses to stimuli that would normally be threatening (Gallagher & Chiba, 1996). In addition, prefrontal brain regions such as the lateral prefrontal cortex (PFC) appear to be involved in down-regulating activation of the amygdala, with a concomitant inhibition of negative emotions. For example, in the same study noted earlier, Ochsner et al. (2002) found greater lateral PFC activation when participants engaged in reappraisal in response to aversive visual stimuli.

However, it has also been observed that when regions in the lateral PFC do not adequately down-regulate subcortical brain regions, maladaptive self-regulation can follow. In particular fMRI studies have used tasks like the Emotional Go/No-Go (EGNG) task to explore neural correlates of the effectiveness of inhibitory behavior regulation. In one form of the EGNG task participants are instructed to press a designated button to certain types of faces and to refrain from pressing the designated button to other types of faces. For example, participants are to press a button to faces not expressing emotion (neutral) and to inhibit responding to negative facial expressions, such as sadness or anger. In another variation of the EGNG, participants are instructed to press a designated button to a certain letter (e.g., 'M') and to refrain from pressing the designated button to another letter (e.g., 'W') while positive valenced, negative valenced, and neutral images are presented in the background. Studies have shown that lateral PFC recruitment can facilitate successful response inhibition (e.g., Aron, Robbins, & Poldrack, 2004). Aron et al. (2004) found that participants routinely engage PFC brain regions to successfully complete inhibition tasks such as the EGNG and Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948), both measures of cognitive control. Comparatively, individuals with damage to PFC brain regions often perform poorly on these tasks (EGNG & WCST; Aron et al., 2004) resulting in a disruption of response inhibition.

Interestingly however, while greater recruitment of lateral PFC has been related to response inhibition, over-recruitment may result in self-regulatory failure for some people. Chester et al. (2016) found evidence that greater recruitment of inhibitory brain regions were related to self-control failure. Specifically, young adults were invited to participate in an fMRI study of EGNG-based response inhibition who had scored either high on a measure of negative urgency or low on the same measure. Negative urgency is a dispositional tendency to respond impulsively when experiencing high levels of negative emotion (Cyders & Smith, 2008). This trait is relevant to response inhibition in the face of negative emotional stimuli because participants must down-regulate emotional responses to negative stimuli while simultaneously inhibiting behavioral responses (No-Go trials on the EGNG). High negative urgency individuals exhibited greater recruitment of the left and right ventrolateral PFC, left and right anterior insula, and bilateral striatum during the No-Go (versus Go) negative trials on the EGNG compared to the low negative urgency group (although task response accuracy did not differ between the two groups). The high negative urgency individuals reported greater alcohol use at 1 month and 12-month follow-up points, and higher right anterior insula activation in particular mediated the relation between negative urgency and one-month and 12-month follow-up alcohol consumption. The anterior insula appears to be engaged during interoceptive awareness of emotional and somatic states (Craig, 2009), and during inhibitory tasks may subserve awareness of inhibitory errors (Chester et al., 2016). This is the first fMRI study to provide insight into why and for whom self-regulation failure occurs in the face of aversive visual stimuli. The study suggests that those susceptible to self-regulatory failure in response to negative emotions - in this case, those scoring high in negative urgency - show high enough levels of recruitment of inhibitory brain regions when engaged in self-control as to promote potentially problematic behavior (higher levels of alcohol use). An analogy often used to understand this process is that of muscles tiring after extensive use; similarly, behavior regulation-related brain regions may "fatigue" when regularly activated. Psychologically speaking, down-regulating negative emotional responses to provocative emotional stimuli while simultaneously attempting to regulate behavioral responses to those stimuli may create a high level of burden for some individuals, making them less adept at effective self-regulation. Longer term, such excessive neural and psychological burden may result in self-regulatory failure, leading to ineffective or maladaptive behavior.

These ideas draw from "ego-depletion" theory (Baumeister & Vohs, 2007; Hagger, Wood, Stiff, & Chatzisarantis, 2010), which posits that behavior regulation, or self-control, draws upon limited mental resources. Once those mental resources become depleted, the theory states, it becomes difficult to self-regulate. The "excessive inhibition" model is a neural derivative of ego depletion theory that seeks to explain how the underlying neural mechanisms play a role in self-control deficits (Chester et al., 2016). What might reduce the likelihood of such "self-regulatory fatigue" (Chester et al., 2016, p. 2) among those with a disposition to respond to negative emotions with potentially problematic behavior?

It has been suggested that urges to use substances like alcohol in response to negative emotions may reflect an unwillingness or inability to experience negative emotions, increasing the likelihood of substance use to avoid or escape such negative emotions (Levin, Luoma, & Haeger, 2015). Consistent with this, a greater ability to tolerate negative emotions may improve self-regulation (and reduce substance use) among high-urgency individuals (Cyders & Smith, 2008). An ability to experience negative emotion is targeted in mindfulness training (Farb, Anderson, & Segal, 2012), and evidence suggests that such tolerance is a significant outcome of such training. The proposed study is an initial effort to explore the role that mindfulness may play in fostering effective behavior regulation among young adults prone to high negative urgency.

Mindfulness

Mindfulness is often referred to as a form of self-regulation of attention. Canonically, it concerns a receptive attentiveness to internal and external stimuli as they arise, moment-to-moment (e.g., Analayo, 2003; Brown et al., 2015). Mindfulness has been related to more effective emotion regulation in both intrapersonal contexts (Arch & Landy, 2015; Corcoran, Farb, Anderson, & Segal, 2009; Holzel et al., 2011) and interpersonal contexts (Barnes, Brown, Krusemark, Campbell, & Rogge, 2007; Quaglia, Goodman, & Brown, 2015). In part this appears to be due to lower emotional reactivity to negative affective stimuli (e.g., Arch & Craske, 2006; 2010). Studies have begun to address this at the neural level. For example, Brown, Goodman, and Inzlicht (2012) found that trait mindfulness, assessed using the well-validated Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), predicted smaller late positive potential (LPP) amplitudes in response to high arousal, negatively valenced visual stimuli from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999). The LPP is an electrocortical marker of early attention to and appraisal of motivationally salient stimuli, appearing approximately 400 ms after stimulus onset. This study suggests that mindfulness may confer an efficient processing of stimuli that dampens "downstream" negative emotional responses. In an fMRI context, Creswell et al. (2007) studied the neural correlates of trait mindfulness (also using the MAAS) during two conditions: affect labeling of facial expressions of negative affect (anger, fear, sadness) versus gender labeling of neutral expression faces (as control trials). Participants scoring higher on MAAS-assessed mindfulness showed less amygdala activation in response to the negative emotional faces (relative to neutral faces), greater activation of lateral PFC in response to these emotional expressions, and an inverse correlation between amygdala and lateral PFC activations. These study results suggest that mindfulness is associated with more efficient top-down processing of socioemotional stimuli as well as inhibition of emotional reactivity to such stimuli.

There is also indication that mindfulness may foster adaptive behavior regulation. For example, in recent years clinicians have begun using mindfulness training for substance use reduction and prevention (Bowen et al., 2009). Excessive use of alcohol and other drugs poses a public health problem that can have a devastating impact on personal well-being and interpersonal relationships. Much of the research examining mindfulness training in the context of substance use has been done among current users, including those addicted to alcohol or cigarettes. One training model, Mindfulness-Based Relapse Prevention (MBRP), combines skills training in cognitive behavioral-based relapse prevention with mindfulness meditation. The mindfulness training component is designed to increase discriminative awareness, specifically focusing on acceptance or tolerance of uncomfortable affective and motivational states or challenging situations without habitually reacting to them (Witkiewitz, Lustyk, & Bowen, 2013). Those authors review evidence from randomized controlled trials showing that, for example, MBRP produced significantly lower rates of substance use, greater decreases in craving following treatment, and no more craving or substance use in response to negative emotions than control participants (see also Bowen et al., 2009). Other studies with the MBRP program have shown less activation in amygdala and greater PFC activation in response to negative stimuli compared to treatment as usual (TAU) conditions. These study findings suggest that mindfulness meditation is associated with enhanced executive functioning, cognitive control, and emotion regulation that acts to inhibit subcortical processing, and less “bottom up” (subcortical-limbic) activation that may subserve reactivity to substance-related or affective stimuli (Westbrook, Creswell, Tabibnia, Julson, Kober, & Tindle, 2013; Witkiewitz, Lustyk, & Bowen, 2013). Interestingly, mindfulness does not appear to eliminate internal experiences that can lead to problematic behaviors, but rather to change the existing relations between internal experiences and other behaviors - a phenomenon that has been termed “decoupling” (Levin at al., 2015; Ostafin & Marlatt, 2008) and “desynchrony” (Hayes, Strosahl, & Wilson, 2011). As Levin et al. (2015, p. 871) describe it, decoupling “is a process by which the normative relationships between an internal experience and another internal experience (e.g., between thoughts and feelings or between feelings and urges) or between an internal experience and overt behavior (e.g., negative affect and smoking) are reduced, eliminated, or altered through changes in the context in which they occur.” Framed this way, mindfulness is theorized to provide a context of receptive, nonreactive attention that changes the functions of internal experiences and their effects on behaviors, without necessarily altering the form of those experiences (Levin et al., 2015).

A number of studies appear to support this decoupling of experience and behavior through mindfulness in the realms of both negative emotional experience (e.g., Arch & Craske, 2010; Feldman et al., 2016; Vujanovic et al., 2007) and substance-related motivational experience (e.g., Bowen & Enkema, 2014; Gonzalez et al., 2009). For example, Ostafin and Marlatt (2008) found that self-reported trait mindfulness moderated the relation between implicit attitudes and alcohol use. Additionally, Gonzalez et al (2009) found that MAAS-assessed trait mindfulness beneficially moderated the relation between the expectation of negative emotional reduction through smoking and both anxious arousal and emotion regulation difficulties among a large sample of daily cigarette smokers. Elwafi et al., (2013) found that mindfulness training eliminated the predictive power of urges to smoke on actual smoking behavior. Levin et al. (2015) review evidence from six trait-based, laboratory, and treatment studies of mindfulness showing its ability to decouple relations between negative emotions, urges to use substances, and substance use behavior.

This evidence base is still thin, and there is even less evidence that mindfulness can modulate the role of urgency in substance use and the neural processes mediating that relation. Yet there is suggestion that mindfulness may serve this function. Murphy and MacKillop (2012) found an inverse association between trait mindfulness and the tendency to act on impulses while experiencing negative emotions, and in fact argue that the two dispositions are “natural reciprocals” (p. 528), as the proneness to act on an impulse is countered by a capacity to observe or objectively experience that impulse without acting. A second suggestive study, by Bowen and Enkema (2014), found that trait mindfulness moderated a positive relation between avoidant coping and severity of substance use in a clinical sample - a result that may be particularly relevant to those with a high urgency disposition, given the avoidance of negative emotions and other aversive experiences that helps to characterize the trait.

Present Study

The present study proposes to build upon this nascent evidence by asking whether, as past research suggests (e.g., Murphy & MacKillop, 2012), trait mindfulness is inversely related to negative urgency and therefore has opposite relations to alcohol use and neural predictors of that alcohol use. In accord with prior evidence indicating that mindfulness moderates relations between avoidant coping and other vulnerability factors and mental and behavioral outcomes (e.g., Bowen & Enkema (2014), the present study aims to explore whether trait mindfulness moderates the relation between negative urgency and both alcohol consumption and the neural mediators of that relation, as revealed by Chester et al. (2016). Specifically, the present study aims to explore whether trait mindfulness (a) directly predicts substance use (while controlling for negative urgency); (b) modulates the higher inhibitory brain region activation among high negative urgency individuals facing negative emotional stimuli, as observed by Chester et al. (2016); and (c) thereby predicts lower alcohol use assessed one and 12 months later among the participants in Chester et al.'s (2016) study. Consistent with theory and the preliminary research presented here, the present study asks the following questions:

Research Question 1: Does MAAS-assessed trait mindfulness predict substance use when controlling for negative urgency?

Research Question 2: Is MAAS-assessed mindfulness related to greater activation in five inhibitory brain regions during EGNG No-Go negative emotional trials in this sample of high and low negative urgency individuals?

Research Question 3: Do the inhibitory brain regions (assessed via BOLD response during EGNG) mediate the relation between MAAS-assessed mindfulness and substance use at the one-month follow-up? Specifically, this question asks whether the relation between mindfulness and substance use is indirectly explained via inhibitory brain regions during No-Go, inhibition response trials of negative emotional stimuli?

Research Question 4: Will high negative urgency individuals with higher MAAS-assessed mindfulness report less substance use? Specifically, this question asks whether MAAS-assessed mindfulness will moderate the recently reported relation between the negative urgency disposition and alcohol consumption reported at a one-month follow-up point (Chester et al., 2016).

Research Question 5: Will trait mindfulness moderate the relation between negative urgency and inhibitory brain regions, as assessed through BOLD response, under conditions of negative emotional trials and behavioral response inhibition? Specifically, this question asks whether individuals scoring higher in negative urgency but also scoring higher on MAAS-assessed trait mindfulness will show less activation in five inhibitory brain regions (c.f., Chester et al., 2016) during EGNG negative emotional trials compared to activations in these brain regions during EGNG negative emotional trials among higher negative urgency individuals with lower levels of MAAS mindfulness.

Research Question 6: Will mindfulness moderate the mediational role of inhibitory brain regions on the relation between negative urgency and substance use? Specifically, this question asks whether the previously reported right anterior insula mediation of the relation between negative urgency and alcohol consumption (Chester et al., 2016) is attenuated among high negative urgency individuals with higher MAAS-assessed mindfulness, relative to high negative urgency individuals with lower MAAS-assessed mindfulness (see Figure 1).

Methods

Participants

Participants were recruited from an introductory psychology participant pool at the University of Kentucky. Participants were screened prior to scheduling a laboratory session and were included into the study if they were right hand dominant and 18 years or older. In order to meet safety protocol participants were excluded from the study if they met any of the following criteria: body mass index was greater than 30, expressed fear of claustrophobia, color-blind, currently taking psychoactive medications, reported a history of psychological or neurological pathology, history of seizures, or expected were pregnant. Participants were recruited into one of four groups based on a 2 (high vs. low negative urgency) by 2 (high vs. low neuroticism) factorial design. 'High' and 'low' group assignments were assessed by scores from the upper and lower halves of the sampling distribution, respectively.

The sample consisted of 80 healthy, right handed undergraduate students whose mean age was 18.77 (SD = .99) with 67.5% identifying as female and 32.5% as male. The ethnic composition of the sample was 77.6% White/Caucasian, 13.2% Black/African American, 6.6% Asian, and 2.6% 'other. Two participants dropped out of the study due to anxiety in the scanner, leaving a final sample of 78 participants. Participants were compensated with course credit and $65 for full study participation.

Procedure

Informed consent was obtained prior to completing any measurements in the laboratory session. Participants then completed the Mindful Attention Awareness Scale (MAAS; Brown &

Ryan, 2003) along with basic demographic information such as age, gender, and race.

Prior to entering the fMRI scanner participants were safety screened again (as per original screening) to ensure their safety to participate in the scanning session. Following the safety screen, eligible participants were acclimated to the fMRI scanner by the research assistant and practiced the EGNG task prior to entering the scanner to ensure their understanding of the task. In the scanner, participants completed the EGNG task (outlined in Measures and Materials subsection below). They were then debriefed and compensated for their participation. A follow-up questionnaire (Alcohol Timeline Follow-back; Sobell and Sobell, 1992) was sent out to participants via e-mail to assess substance use at one month and again at 12 months after the laboratory visit.

Measures and Materials

Negative Urgency. Before the laboratory session, participants completed the 12-item negative urgency subscale of the UPPS-P Impulsivity Scale (Lynam et al., 2006; Whiteside and Lynam, 2001). This subscale measures dispositional differences in the tendency to act impulsively under conditions of negative affect. Participants rated each item from 1 (*Disagree Strongly*) to 4 (*Agree Strongly*) on a Likert-type scale. Sample items include “When I am upset I often act without thinking” and “In the heat of an argument, I will often say things that I later regret.” This subscale has shown excellent internal reliability (Cyders & Smith, 2010). After reverse-scoring relevant items, all 12 responses were averaged together to create a negative urgency score for each participant that could range from 1 to 4, with higher scores indicating a higher level of impulsivity under conditions of negative affect.

Neuroticism. This construct was also assessed pre-laboratory visit. To measure neuroticism, the tendency to experience greater negative affect, participants completed the 10-item Neuroticism subscale of the Big Five Inventory (John & Srivastava, 1999). Participants were instructed to rate each item on a 4-point Likert scale ranging from 1 (*Disagree Strongly*) to 4 (*Agree Strongly*). After reverse-scoring relevant items, all 10 responses were averaged together to create a neuroticism score for each participant that could range from 1 to 4, with higher scores indicating a higher level of neuroticism.

Mindfulness. Completed near the start of the laboratory session, the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003) is a 15-item scale measuring a basic operationalization of dispositional mindfulness by assessing receptive attention to, and awareness of present moment events and experiences (example item, "I find it difficult to stay focused on what is going on in the present moment"). Items were rated from 1 (*almost always*) to 6 (*almost never*) where higher scores indicate a higher level of dispositional mindfulness. The MAAS has shown good internal consistency ($\alpha \geq .82$) and 4-week test–retest reliability (interclass $r = .81$) and is positively correlated with number of years of meditation practice ($r = .36$, $p < .05$) (Brown & Ryan, 2003).

Alcohol Use. To assess participants' typical alcohol use, participants completed two online follow-back calendars one month and twelve months after their scan (Sobell and Sobell, 1992). Participants were trained on how to complete the calendars during their initial laboratory visit. Participants were instructed to record how many alcoholic beverages they consumed each day for the given month. A conversion chart was provided which allowed the participants to determine how many drinks a given amount of beer, wine, liquor, or malt liquor consisted of. The number of post-scan drinks was averaged across each day of the month because the number of days in a given month differed for each subject, yielding two alcohol consumption scores (at one-month and 12-month post scan).

Emotion Go/No Go Task (EGNG)

The EGNG task is meant to measure behavioral inhibition and emotional modulation of inhibitory responses to various emotional stimuli. Participants were instructed to press a button whenever they viewed the letter ‘M’ (Go trials) and to not press the button when they viewed the letter ‘W′ (No-Go trials). These letters were overlaid atop images from International Affective Picture System (IAPS; Lang et al., 1999) that were selected based on pre- ratings of high, average, or low pleasantness, so as to elicit positive, neutral, and negative affective valences during the EGNG task. Negative stimuli included images such as frightening animals, human corpses, and visibly distraught and suffering individuals. Social stimuli were included in all three stimulus categories. Stimuli were matched for arousal level across the three valences. This task design yielded a 2 (response: Go vs. No-Go) by 3 (valence: negative vs. neutral vs. positive) within-subjects factorial design yielding 6 conditions. There were 198 total trials each lasting 2.5 s (total task duration: 8 min, 15 s); 132 trails were experimental trials and 66 were simple fixation trials. Of the 132 experimental trials, 93 were Go trials and 39 were No-Go trials, split evenly by affective valence. The order of trials was randomized and held constant across participants.

In each trial, participants were cued to Go or No-Go responses with “M” and “W” letters as earlier indicated, while simultaneously being primed with affect-eliciting image (1 s). Then, the response cue was replaced by a fixation cross while the affect-eliciting image remained (1 s). This allowed control for neural responses to the image itself. The image then disappeared and only the fixation cross remained on the screen (0.5 s). Average accuracy rates were high across all conditions (ranging from 97.13% to 99.40%), likely due to the slower pace of each trial compared to the usual, response time-based EGNG task. This slower pace was required to accurately estimate BOLD response in fMRI.

fMRI Data Acquisition

Functional brain images were collected on a 3-Tesla Siemens MAGNETOM Trio MRI scanner using a T2*-weighted gradient echo planar imaging sequence with the following acquisition parameters: 64 × 64 matrix size, 224 × 224 mm field of view, 28 ms echo time, 2.5 s repetition time, 40 3.5 mm axial slices acquired, and 90° flip angle, following a 3D shim, in interleaved order which allowed for whole brain coverage. A high-resolution, 3D T1-weighted MPRAGE anatomical imageset was also acquired from each participant with the following parameters: 1 mm isotropic voxels, 2.56 ms echo time, 1.69 s repetition time, and 12° flip angle.

Preprocessing

The Oxford Center for Functional MRI of the Brain (fMRIB) Software Library (FSL version 5.0) was used to conduct all preprocessing and fMRI analyses (Jenkinson et al., 2012; Smith et al., 2004; Woolrich et al., 2009). Reconstructed functional volumes underwent head motion correction to the median functional volume and were skull stripped. Functional volumes underwent slice-timing correction, pre-whitening, were smoothed with a 5-mm FWHM Gaussian kernel, and were then high-pass filtered (100 s cutoff). Non-brain structures were then stripped from the reconstructed anatomical imageset.

Data Analysis Plan

Prior to any statistical analyses the data univariate frequencies were conducted to ensure the data met assumptions of normality. There were a few outliers in the substance use data and therefore the upper four (most extreme) data points were windorized in order to meet assumptions of normality, bringing skewness and kurtosis scores back down to appropriate scores.

To test the first research question asking whether mindfulness predicts substance use when controlling for negative urgency, we conducted three statistical tests. In order to first understand if there is a meaningful difference between high and low negative urgency groups on mindfulness, an independent samples t-test was conducted. A difference in trait mindfulness between the two groups, such higher negative urgency is associated with lower mindfulness, would preliminarily suggest that the two dispositions are opposing (c.f., Murphy & MacKillop, 2012) and may differentially predict substance use. The second statistical test was bivariate correlation analysis to assess the relation among the following variables: mindfulness, negative urgency, neuroticism, and substance use at the one-month follow-up. Finally, a hierarchical linear regression analysis was conducted to test whether mindfulness explained additional variance to the dependent variable (substance use) when controlling for negative urgency (and gender).

To test the second research question asking whether mindfulness was related to inhibitory brain region activations during negative affective, inhibitory trials of the Emotional GNGO task, bivariate correlation analyses were conducted to assess the relations between mindfulness and the activations in the following regions (Chester et al., 2016): right anterior insula, left anterior insula, right VLPFC, left VLPFC, and dorsal striatum.

To test the third research question asking whether inhibitory brain region activations mediated the relation between mindfulness and substance use, a mediation analysis was proposed using a bootstrapping approach (PROCESS plug-in for SPSS; Hayes, 2013).

To test the fourth research question whether trait mindfulness will moderate the relation between negative urgency and substance use, moderation analyses were performed. Specifically, this analysis asked whether individuals scoring higher in negative urgency and also scoring higher on MAAS-assessed trait mindfulness will report less substance use compared to individuals higher in negative urgency but lower on MAAS-assessed trait mindfulness. Again, the above-noted bootstrapping approach was used to test for moderation.

To test the fifth research question whether trait mindfulness will moderate the relation between negative urgency and inhibitory brain regions, as assessed through BOLD response, under conditions of negative emotional trials and behavioral response inhibition, moderation analyses were performed. Specifically, this analysis asked whether individuals scoring higher in negative urgency but also scoring higher on MAAS-assessed trait mindfulness will show less activation in the previously noted five inhibitory brain regions during EGNG negative emotional trials compared to activations in these brain regions during EGNG negative emotional trials among higher negative urgency individuals with lower levels of MAAS mindfulness. Again, bootstrapping was used to test for moderation.

Finally, to test the sixth research question asking if mindfulness will moderate the mediational role of inhibitory brain regions on the relation between negative urgency and substance use, a moderated mediation analysis was performed using a bootstrapping approach (PROCESS for SPSS; Hayes, 2013). Specifically, this analysis was designed to ask whether the previously reported right anterior insula mediation of the relation between negative urgency and alcohol consumption (Chester et al., 2016) was attenuated among high negative urgency individuals with higher MAAS-assessed mindfulness, relative to high negative urgency individuals with lower MAAS-assessed mindfulness (see Figure 1).

Results

Research Question 1: Does mindfulness predict substance use when controlling for negative urgency? Prior to answering this research question it was important to first test whether there were meaningful differences on level of mindfulness between high and low negative urgency groups. The independent-groups t-test found significant differences between high (*M* = 3.37, *SD* = .68) and low (*M* = 4.19, *SD* = .81) Negative Urgency (NU) on MAAS-assessed mindfulness. The low NU group exhibited higher mindfulness scores than did the high NU group, $t(62) = -4.37$, $p < .001$, *d = 1.09.* I then assessed whether mindfulness and substance use at one-month and 12-month follow-ups were significantly related to each other prior to testing a predictive relation. Table 1 shows a significant moderate negative correlation between mindfulness and substance use at the one month follow up, $r(55) = -.32$, $p = .015$, $R^2 = .09$ (see Figure 2 for scatterplot). However, there was only a marginally significant relation between mindfulness and substance use at the 12-month follow-up, $r(43) = -.27$, $p = .069$.

To investigate whether mindfulness predicted substance use when controlling for negative urgency and gender, a hierarchical linear regression analysis was conducted. When negative urgency and gender were entered into the first block of the model, they significantly predicted substance use, $F(2, 54) = 5.48$, $p = .007$, $R^2 = .017$. However, as indicated by the R^2 only 1.7% of the variance in substance use could be predicted by knowing levels of negative urgency and gender. When mindfulness was added to the model in the second block, it significantly improved the prediction, $\Delta R^2 = .029$, $\Delta F(3, 53) = 4.35$, $p = .008$.

Research Question 2: Is MAAS-assessed mindfulness related to greater activation in the five inhibitory brain regions of interest during EGNG No-Go negative emotional trials in this sample of high and low negative urgency individuals? Table 1 shows that there was a significant negative relation between mindfulness and dorsal striatum activation, $r(62) = -.28$, $p = .023$. Higher mindfulness was associated with lower striatal activation during No-Go negative emotional trials of the EGNG task. However, there were no significant relations between mindfulness and activations in the other four inhibitory brain regions of interest during inhibitory (No-Go) trials of the Emotional Go/No-Go task (see Table 1).

Research Question 3: Do the inhibitory brain regions (assessed via BOLD response during No-Go trials of the EGNG) mediate the relation between MAAS-assessed mindfulness and substance use at the one-month follow-up? Bivariate correlation analyses showed no relation between dorsal striatum activation and 1-month reported substance use (see Table 1); therefore it was no longer appropriate to test whether inhibitory brain region activations mediated the relation between mindfulness and substance use.

Research Question 4: Will high negative urgency individuals with higher MAAS- assessed mindfulness report less substance use? To test for moderation of the relation between negative urgency and substance use by mindfulness, both the Baron and Kenny (1986) approach and a bootstrapping approach (Hayes, 2013) were used. Using the Baron and Kenny method, a hierarchical regression analysis evaluated the moderating role of mindfulness on the relation between negative urgency and 1-month substance use. Prior to analyses, the continuous MAAS score was centered and a product term created from the dichotomous NU variable (coded 0, 1) and the centered MAAS score (Baron & Kenny, 1986). Negative urgency and the moderator variable (MAAS) were entered into the first block as main effects. Next, the product term was entered into the second block. The overall model was significant, $\Delta R^2 = .044$, $F(3,53) = 4.13$, $p = .011$. Negative urgency was unrelated to substance use, $\beta = -.24$, $t(56) = -1.44$, $p = .155$. Mindfulness was likewise unrelated to substance use after controlling for negative urgency, $\beta = -.01$, $t(56) = .01$, $p = .989$. Finally, the association between negative urgency and substance use was not moderated by mindfulness, $\beta = -.53$, $t(56) = -1.64$, $p = .108$.

While nonsignificant, the interaction was probed by testing the conditional effects of negative urgency at three levels of mindfulness, one standard deviation below the mean, at the mean, and one standard deviation above the mean. As shown in Table 2, negative urgency was significantly related to substance use when mindfulness was one standard deviation below the mean (p = .021), but not significantly related when at the mean level of mindfulness (p = .094), and not when mindfulness was one standard deviation above the mean (p = .998).

Research Question 5: Will trait mindfulness moderate the relation between negative urgency and inhibitory brain region activations, as assessed through BOLD response, under conditions of negative emotional trials and behavioral response inhibition? To test this research question, bivariate correlation analyses first examined the relations between the mindfulness x NU interaction term (MAAS x NU), inhibitory brain regions, and substance use at the one-month follow-up point. Table 1 showed that the interaction term (MAAS x NU) was significantly correlated with all inhibitory brain regions: right anterior insula, left anterior insula, right Ventrolateral Prefrontal Cortex (VLPFC), left VLPFC, and dorsal striatum. However, it was not appropriate to further test this research question because bivariate correlations showed no significant relation between the mindfulness x NU moderator variable and 1-month post-session substance use.

Research Question 6: Will mindfulness moderate the mediational role of inhibitory brain regions on the relation between negative urgency and substance use? It was not appropriate to test this final research question based on the non-significant bivariate correlations between dorsal striatum and substance use.

Discussion

This thesis presented the first study to examine the role of mindfulness in substance use, and the neural mechanisms thereof, among individuals susceptible to negative urgency relative to those who are not. The study aimed to understand whether mindfulness may serve to protect high negative urgency individuals against maladaptive self-regulation of behavior (such as engaging in higher levels of substance use) in the face of negative affect. An important first step in asking whether mindfulness may be such a protective factor is to examine how trait mindfulness and trait negative urgency are related and how they potentially interact with each other to predict self-regulatory failures. The thesis tested 6 research questions, the results of which are discussed next.

It was important to first differentiate mindfulness from negative urgency since the two variables are posited to be inversely related (Murphy & MacKillop, 2012). Results indicated there was a meaningful difference in the level of mindfulness between high and low negative urgency groups, such that the low negative urgency group exhibited higher levels of mindfulness. Next, we assessed the nature of the relation between mindfulness (measured via MAAS; Brown & Ryan, 2003) and substance use. MAAS scores showed a moderate negative correlation with substance use at the one-month follow-up, but not at the 12-month follow-up point. Finally, hierarchical linear regression analysis showed that mindfulness predicted substance use above and beyond gender and negative urgency. These results are consistent with Murphy and MacKillop's (2012) finding that trait mindfulness is inversely related to the tendency to act on impulses while experiencing negative affect. Additionally, the present study extends those authors' findings by providing evidence that mindfulness negatively predicts substance use while negative urgency positively predicted substance use in the same model. Interestingly, Vinci et al. (2016) found that a brief mindfulness intervention moderated the relation between negative urgency and urge to drink in college students, such that individuals high in negative urgency showed a greater urge to drink post-mindfulness intervention. In another study assessing the effectiveness of brief mindfulness instruction on coping with urges to smoke, Bowen and Marlatt (2009) found that current smokers enrolled in either a mindfulness training or a control training did not differ significantly on the urge to smoke post training. However, the two groups did differ on number of cigarettes smoked in the week following the lab session. Specifically, mindfulness trainees smoked significantly less cigarettes over the week compared to the control trainees. Therefore, it appears that mindfulness may not decrease the urge to smoke, but it may regulate behavioral responses to such urges. Altogether these findings call for a closer examination of the relations between mindfulness, negative urgency, and substance use. This is a critical first step in understanding whether mindfulness can facilitate adaptive behavior regulation specifically concerning alcohol consumption in individuals prone to negative urgency.

The study found that MAAS-assessed mindfulness was negatively correlated with dorsal striatal activation during no-go trials of negative emotional in the EGNG task, but was not related to activations in the other four inhibitory brain regions examined (right and left anterior insula, right and left VMPFC).

Extant literature on striatum suggests that one of its main functions involves voluntary motor movement, which is consistent with the nature of the EGNG task. Aron (2011) posited that greater striatum activation is thought to function as proactive, selective response-stopping in inhibitory tasks such as EGNG. However, the negative relation between mindfulness and striatum activation may be a function of reward sensitivity. Moeller et al. (2016) found that lower activation in subcortical inhibitory brain regions such as putamen and globus pallidus (part of the striatum) during a response inhibition task predicted abstinence-related behavior in currently addicted individuals. Kirk, Brown, and Downer (2015) compared neural activation during a monetary-incentive delay task between mindfulness meditators and matched non-meditators and found less striatal (and other reward network) activation in meditators during anticipation and receipt of monetary reward. These results suggest that mindfulness meditators are less sensitive to certain forms of reward, as reflected in lower striatal activation.

The bivariate correlation analyses served as a preliminary test of whether inhibitory brain regions mediated the relation between mindfulness and substance use. These results showed that mindfulness was not related to right anterior insula, left anterior insula, right ventrolateral prefrontal cortex, and left prefrontal cortex. While mindfulness did predict lower striatal activation on No-Go negative emotional trials, striatum activation did not predict substance use. Thus it was not appropriate to examine research question 3 concerning inhibitory brain region (and specifically dorsal striatal) mediation of the relation between mindfulness and substance use. However correlation analyses showed significant relations between mindfulness, negative urgency, and substance use, and thus it was appropriate to test whether high negative urgency individuals with higher MAAS-assessed mindfulness reported less substance use. The moderation of the negative urgency – substance use relation by trait mindfulness was non-significant overall, but simple slopes analysis showed that at one standard deviation below sample mean mindfulness, the relation between negative urgency and substance use was significant, such that negative urgency predicted substance use at low levels of mindfulness. One explanation for this weak finding could be the low statistical power for moderation analyses, as only a subset of the total sample of participants completed the MAAS. Yet the results provide preliminary evidence that mindfulness may serve to protect individuals against maladaptive forms of self-regulation, but more research needs to be conducted to better understand the role mindfulness may play in samples of individuals particularly vulnerable to self-regulatory failure.

Interestingly, the interaction mindfulness and negative urgency was positively related to all five inhibitory brain regions examined (right insula, left insula, right VLPFC, left VLPFC, and striatum). Yet this interaction term was not significantly related to substance use at the one-month follow-up, indicating a lack of evidence that mindfulness moderated the mediational pathway from negative urgency to inhibitory brain region activation to substance use. Again, with a larger sample such moderated mediation analyses may be more fruitful.

The present study's results, though limited, begin to inform how mindfulness may enhance behavior regulation among those prone to regulatory failure under conditions of negative affect. Chester et al. (2016) found that individuals high in negative urgency exhibited self-regulatory failures in the face of difficult emotional states, hypothesized to due to overtaxing inhibitory brain regions. This resulted in greater substance use for those high in negative urgency compared to the low negative urgency group. The results of this study speak to whether mindfulness may reduce the likelihood of such "self-regulatory fatigue" (Chester et al., 2016, p. 2) among those with a disposition to respond to negative affective stimuli with potentially problematic behavior. It is important to note that although negative urgency and mindfulness seem to be inversely related, the two constructs are not anti-correlated. For instance, it is possible that one may score high on trait mindfulness but also score high on negative urgency. Therefore, it is important to ask what the behavioral co-expression of both constructs would look like? Smith and Cyders (2016) suggest that interventions that focus on interrupting the progression from distress to rash action may be beneficial in understanding relations between negative urgency and mindfulness in the context of substance related behaviors. Bowen and Marlatt's (2009) findings may help further explain the role of mindfulness on the relation between negative urgency and substance use. Although, their mindfulness and control conditions did not differ on the urge to smoke, they did differ on the number of cigarettes smoked in the week following the training. These findings support the notion of mindfulness aiding in the "decoupling" of substance use-related experiences and behavior. Although Bowen and Marlatt's (2009) study did not directly examine the role of negative urgency, it is possible that those scoring high in negative urgency (or those who otherwise have the tendency to make rash or regrettable decisions in the face of negative affect) may still have the urge to act rashly; but if they are also more mindful individuals, those urges may not result in maladaptive behavior. Mindfulness Based Relapse Prevention programs focus on training individuals to be accepting and tolerant of distressful affective states in response to environmental triggers. Therefore, mindfulness-based interventions may be particularly appropriate to further explore the co-occurance of high negative urgency and high trained mindfulness in understanding how to modulate maladaptive behavioral responses to negative emotional experiences.

Prior work in this area has been minimal, but Friese, Messner, and Schaffner (2012) examined the short-term effects of mindfulness in the face of limited mental resources. Participants who were depleted of mental resources after completing an emotion suppression task performed worse on a later self-control task compared to individuals who briefly meditated after they completed the emotion suppression task. These findings suggest that brief mindfulness training may be an efficient strategy to use during times when mental resources are low or depleted.

Limitations and Future Research

There were several features of this study that limited its conclusions. The study was poorly powered to test moderation and mediation. Only 65 participants completed the MAAS measure of trait mindfulness. Thus, a more strongly powered study is needed to adequately test research questions concerning the moderating and moderated mediation role of mindfulness in relations between negative urgency and substance uses. Another important limitation to note is that the sample consisted of young adult college students. The distributional range of substance use scores at the one-month follow up was restricted, such that some were not using alcohol and/or other substances substance use (n = 13) or only to a limited extent (such as 1-4 drinks per episode, on average). Therefore, sampling from subclinical and clinical populations that have more severe substance use issues may provide a stronger test of the research questions concerning mindfulness.

Additionally, mindfulness was operationalized using a self-report scale, and similar to all extant self-report measures of the construct it is tapping into a very basic form of mindfulness (Brown et al., 2011). It would be valuable for future research to use more objective measurement strategies to better understand how mindfulness impacts emotion regulation and self-regulation. Additionally an appropriate goal of this program of research is to understand how mindfulness training can improve self-regulation of problematic behavior, and thus future research could examine how mindfulness training could be implemented to assess salutary changes in self-regulation of problematic behavior.

The extreme groups design of the present study presents important limitations to note. In accord with this design, negative urgency was dichotomized, which may have contributed to insufficient power to test the mindfulness-based moderation and mediation analyses. By dichotomizing a continuous variable, we also potentially lose variability in the outcomes of interest (here, brain activations and substance use). Finally, reducing negative urgency to two groups conceals any non-linearity between negative urgency, or inhibitory brain regions, and substance use. For these reasons, future research would do well to measure negative urgency on a continuum to address these shortcomings.

Conclusions

The present study provided preliminary evidence to show that trait mindfulness predicts lower substance use in a vulnerable population. The results shed light on the potential of mindfulness to facilitate healthy behavior regulation among a group prone to self-regulatory deficits when confronted with negative affective states. The study had are a number of important limitations that should be overcome to further explore the role that mindfulness plays in facilitating healthy regulation among those prone to negative urgency. Since emotion regulatory and self-regulatory processes unfold rapidly and are often difficult to self-report when experienced, it will be important to continue to examine these processes at the neural level. Experimental, mindfulness training research in this area with appropriately powered sample sizes will be particularly valuable to advance this important line of inquiry.

References

Anālayo. (2003). *Satipaṭṭhāna: The direct path to realization*. Windhorse Publications.

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: Emotion regulation following a focused breathing induction. *Behaviour Research and Therapy*, *44*(12), 1849-1858.

Arch, J. J., & Craske, M. G. (2010). Laboratory stressors in clinically anxious and non-anxious individuals: The moderating role of mindfulness. *Behaviour Research and Therapy*, *48*(6), 495-505.

Arch, J. J., & Landy, L. N. (2015). Emotional benefits of mindfulness. *Handb. Mindfulness Theory Research Practice*, 208-224.

Aron, A. R. (2011). From reactive to proactive and selective control: Developing a richer model for stopping inappropriate responses. *Biological Psychiatry*, *69*(12), e55-e68.

Aron, A. R., Robbins, T. W., & Poldrack, R. A. (2004). Inhibition and the right inferior frontal cortex. *Trends in Cognitive Sciences*, *8*(4), 170-177.

Balodis, I. M., & Potenza, M. N. (2015). Anticipatory reward processing in addicted populations: a focus on the monetary incentive delay task. *Biological Psychiatry*, *77*(5), 434-444.

Barnes, S., Brown, K. W., Krusemark, E., Campbell, W. K., & Rogge, R. D. (2007). The role of mindfulness in romantic relationship satisfaction and responses to relationship stress. *Journal of Marital and Family Therapy*, *33*(4), 482-500.

Baumeister, R. F., & Vohs, K. D. (2007). Self-Regulation, ego depletion, and motivation. *Social and Personality Psychology Compass*, *1*(1), 115-128.

Beck, A., Schlagenhauf, F., Wüstenberg, T., Hein, J., Kienast, T., Kahnt, T., ... & Wrase, J. (2009). Ventral striatal activation during reward anticipation correlates with impulsivity in alcoholics. *Biological Psychiatry*, *66*(8), 734-742.

Bowen, S., Chawla, N., Collins, S. E., Witkiewitz, K., Hsu, S., Grow, J., ... & Marlatt, A. (2009). Mindfulness-based relapse prevention for substance use disorders: A pilot efficacy trial. *Substance Abuse*, *30*(4), 295-305.

Bowen, S., & Enkema, M. C. (2014). Relationship between dispositional mindfulness and substance use: Findings from a clinical sample. *Addictive Behaviors*, *39*(3), 532-537.

Bowen, S., & Marlatt, A. (2009). Surfing the urge: Brief mindfulness-based intervention for college student smokers. *Psychology of Addictive Behaviors*, *23*(4), 666-671.

Brewer, J. A., Mallik, S., Babuscio, T. A., Nich, C., Johnson, H. E., Deleone, C. M., ... & Carroll, K. M. (2011). Mindfulness training for smoking cessation: Results from a randomized controlled trial. *Drug and Alcohol Dependence*, *119*(1), 72-80.

Brewer, J. A., Sinha, R., Chen, J. A., Michalsen, R. N., Babuscio, T. A., Nich, C., ... & Carroll, K. M. (2009). Mindfulness training and stress reactivity in substance abuse: Results from a randomized, controlled stage I pilot study. *Substance Abuse*, *30*(4), 306-317.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*(4), 822-848.

Brown, K.W., Ryan, R.M., Loverich, T.M., Biegel, G.M., & West, A.M. (2011). Out of the armchair and into the streets: Measuring mindfulness advances knowledge and improves interventions: Reply to Grossman (2011). *Psychological Assessment*, *23*, 1041-1046.

Brown, K. W., Weinstein, N., & Creswell, J. D. (2012). Trait mindfulness modulates neuroendocrine and affective responses to social evaluative threat. *Psychoneuroendocrinology*, *37*(12), 2037-2041.

Cameron, L. D., & Jago, L. (2008). Emotion regulation interventions: A common-sense model approach. *British Journal of Health Psychology*, *13*(2), 215-221.

Chatzisarantis, N. L., & Hagger, M. S. (2007). Mindfulness and the intention-behavior relationship within the theory of planned behavior. *Personality and Social Psychology Bulletin*, *33*(5), 663-676.

Chester, D. S., Lynam, D. R., Milich, R., Powell, D. K., Andersen, A. H., & DeWall, C. N. (2016). How do negative emotions impair self-control? A neural model of negative urgency. *NeuroImage*, *132*, 43-50.

Corcoran, K. M., Farb, N. A., Anderson, A., & Segal, Z. (2009). Mindfulness and emotion regulation. *Emotion Regulation and Psychopathology*, 339-355.

Craig, A. D. (2009). How do you feel—now? the anterior insula and human awareness. *Nature Reviews Neuroscience*, *10*(1), 59-70.

Creswell, J. D., Way, B. M., Eisenberger, N. I., & Lieberman, M. D. (2007). Neural correlates of dispositional mindfulness during affect labeling. *Psychosomatic Medicine*, *69*(6), 560-565.

Cyders, M. A., & Smith, G. T. (2008). Emotion-based dispositions to rash action: positive and negative urgency. *Psychological Bulletin*, *134*(6), 807-828.

Elwafi, H. M., Witkiewitz, K., Mallik, S., Thornhill IV, T. A., & Brewer, J. A. (2013). Mindfulness training for smoking cessation: Moderation of the relationship between craving and cigarette use. *Drug and Alcohol Dependence*, *130*(1), 222-229.

Farb, N. A., Anderson, A. K., & Segal, Z. V. (2012). The mindful brain and emotion regulation in mood disorders. *The Canadian Journal of Psychiatry*, *57*(2), 70-77.

Feldman, G., Lavallee, J., Gildawie, K., & Greeson, J. M. (2016). Dispositional mindfulness uncouples physiological and emotional reactivity to a laboratory stressor and emotional reactivity to executive functioning lapses in daily life. *Mindfulness*, *7*(2), 527-541.

Friese, M., Messner, C., & Schaffner, Y. (2012). Mindfulness meditation counteracts self-control depletion. *Consciousness and Cognition*, *21*(2), 1016-1022.

Gallagher, M., & Chiba, A. A. (1996). The amygdala and emotion. *Current Opinion in Neurobiology*, *6*(2), 221-227.

Gonzalez, A., Vujanovic, A. A., Johnson, K. A., Leyro, T. M., & Zvolensky, M. J. (2009). The role of mindful attention in regard to the relation between negative affect reduction outcome expectancies and emotional vulnerability among adult cigarette smokers. *Cognitive Therapy and Research*, *33*(6), 645-656.

Grant, D. A., & Berg, E. (1948). A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a Weigl-type card-sorting problem. *Journal of Experimental Psychology*, *38*, 404-411.

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin*, *136*, 495-525.

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford Press.

Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (2011). *Acceptance and commitment therapy: The process and practice of mindful change*. Guilford Press.

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, *6*(6), 537-559.

Jenkinson, M., Beckmann, C.F., Behrens, T.E.J., Woolrich, M.W., & Smith, S.M., (2012). FSL. *NeuroImage* 62 (2), 782–790.

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

John, O. P., & Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. *Handbook of Personality: Theory and Research*, *2*(1999), 102-138.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1999). International affective picture system (IAPS): Instruction manual and affective ratings. *The Center for Research in Psychophysiology, University of Florida*.

Levin, M. E., Luoma, J. B., & Haeger, J. A. (2015). Decoupling as a mechanism of change in mindfulness and acceptance: a literature review. *Behavior Modification*, *39*(6), 870-911.

Lynam, D. R., Smith, G. T., Whiteside, S. P., & Cyders, M. A. (2006). The UPPS-P: Assessing five personality pathways to impulsive behavior. *West Lafayette, IN: Purdue University*.

Moeller, S. J., Bederson, L., Alia-Klein, N., & Goldstein, R. Z. (2016). Neuroscience of inhibition for addiction medicine: from prediction of initiation to prediction of relapse. *Progress in Brain Research*, *223,* 165-188.

Murphy, C., & MacKillop, J. (2012). Living in the here and now: Interrelationships between impulsivity, mindfulness, and alcohol misuse. *Psychopharmacology*, *219*(2), 527-536.

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. (2002). Rethinking feelings: An FMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience*, *14*(8), 1215-1229.

Ostafin, B. D., Marlatt, G. A., & Greenwald, A. G. (2008). Drinking without thinking: An implicit measure of alcohol motivation predicts failure to control alcohol use. *Behaviour Research and Therapy*, *46*(11), 1210-1219.

Otto, M. W., O'Cleirigh, C. M., & Pollack, M. H. (2007). Attending to emotional cues for drug abuse: Bridging the gap between clinic and home behaviors. *Science & Practice Perspectives*, *3*(2), 48-55.

Quaglia, J. T., Goodman, R. J., & Brown, K. W. (2015). Trait mindfulness predicts efficient top-down attention to and discrimination of facial expressions. *Journal of Personality*, *84*(3), 393-404.

Quickel, E. J., Johnson, S. K., & David, Z. L. (2014). Trait mindfulness and cognitive task performance. *SAGE Open*, *4*(4), 1-8.

Robinson, J. M., Ladd, B. O., & Anderson, K. G. (2014). When you see it, let it be: Urgency, mindfulness and adolescent substance use. *Addictive Behaviors*, *39*(6), 1038-1041.

Sheppes, G., & Gross, J. J. (2011). Is timing everything? Temporal considerations in emotion regulation. *Personality and Social Psychology Review*, *15*(4), 319-331.

Smith, S.M., Jenkinson, M., Woolrich, M.W., Beckmann, C.F., Behrens, T.E.J., Johansen-Berg, H., ... & Matthews, P.M. (2004). Advances in functional and structural MR image analysis

Sobell, L. C., & Sobell, M. B. (1992). Timeline follow-back. In *Measuring alcohol consumption* (pp. 41-72). Humana Press.

Taren, A. A., Creswell, J. D., & Gianaros, P. J. (2013). Dispositional mindfulness co-varies with smaller amygdala and caudate volumes in community adults. *PLoS One*, *8*(5), 1-7.

Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. *Monographs of the Society for Research in Child Development*, *59*(2-3), 25-52.

Vinci, C., Peltier, M., Waldo, K., Kinsaul, J., Shah, S., Coffey, S. F., & Copeland, A. L. (2016). Examination of trait impulsivity on the response to a brief mindfulness intervention among college student drinkers. *Psychiatry Research, 242*, 365-374.

Vujanovic, A. A., Zvolensky, M. J., Bernstein, A., Feldner, M. T., & McLeish, A. C. (2007). A test of the interactive effects of anxiety sensitivity and mindfulness in the prediction of anxious arousal, agoraphobic cognitions, and body vigilance. *Behaviour Research and Therapy, 45*(6), 1393-1400.

Way, B.M., Creswell, J.D., Eisenberger, N.I., Lieberman, MD. (2010) Dispositional mindfulness and depressive symptomatology: Correlations with limbic and self referential neural activity at rest. *Emotion, 10*, 12–24.

Westbrook, C., Creswell, J. D., Tabibnia, G., Julson, E., Kober, H., & Tindle, H. A. (2013). Mindful attention reduces neural and self-reported cue-induced craving in smokers. *Social Cognitive and Affective Neuroscience*, *8*(1), 73–84.

Whiteside, S. P., & Lynam, D. R. (2001). The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences*, *30*(4), 669-689.

Witkiewitz, K., Lustyk, M. K. B., & Bowen, S. (2013). Retraining the addicted brain: A review of hypothesized neurobiological mechanisms of mindfulness-based relapse prevention. *Psychology of Addictive Behaviors*, *27*(2), 351-576.

Witkiewitz, K., Marlatt, G. A., & Walker, D. (2005). Mindfulness-based relapse prevention for alcohol and substance use disorders. *Journal of Cognitive Psychotherapy*, *19*(3), 211-228.

Westbrook, C., Creswell, J. D., Tabibnia, G., Julson, E., Kober, H., & Tindle, H. A. (2013). Mindful attention reduces neural and self-reported cue-induced craving in smokers. *Social Cognitive and Affective Neuroscience*, *8*(1), 73-84.

Woolrich, M.W., Jbabdi, S., Patenaude, B., Chappell, M., Makni, S., Behrens, T., ... & Smith, S.M. (2009). Bayesian analysis of neuroimaging data in FSL. *NeuroImage, 45,* 173–186.

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition*, *19*(2), 597-605.

Tables

Table 1

Intercorrelations among Mindfulness, Negative Urgency, Neuroticism, Inhibitory Brain Regions, and Substance Use.

Measure	1	2	3	4	5	6	7	8	9	10	11
1. MAAS	-										
2. NU	-.49**	-									
3. MAAS*NU	.71**	-.36**	-								
4. Neuroticism	-.16	.14	-.10	-							
5. 1-mo SU	-.31**	.31*	-.38**	.05	-						
6. 12-mo SU	-.27	.18	-.33*	.16	.69**	-					
7. Right Insula	-.08	.38**	-.14	.21	.21	.20	-				
8. Left Insula	-.06	.36**	-.01	.23	.01	.15	.83**	-			
9. Left VLPFC	-.04	.39**	.04	.26*	.05	.10	.77**	.86**	-		
10. Right VLPFC	-.08	.39**	-.13	.18	.12	.09	.91**	.82**	.76**	-	
11. Striatum	-.28*	.48**	-.28*	.15	.16	.13	.60**	.61**	.64**	.65**	-

Note. N = 64. MAAS = Mindfulness; NU = Negative Urgency; 1-mo SU = Substance Use at 1 month follow-up; 12-mo SU = Substance Use at 12 month follow-up; VLPFC = Ventrolateral Prefrontal Cortex.
*p< .05, **p < .001.

Table 2

Multiple Regression Results Showing Substance Use Prediction by Negative Urgency, Mindfulness, and their Interaction

Predictor	*β*	*p*	95% CI	
MAAS	-.278	.063	-.572	.016
NU	.414	.094	-.073	.902
MAAS x NU	-.486	.097	-1.062	.091

Note MAAS = Mindfulness; NU = Negative Urgency.

Table 3

Moderating Role of Mindfulness on the Relation of Negative Urgency and Substance Use

Mindfulness	*β*	*p*	95% CI	
One SD below mean	.828	.021*	.132	1.523
At the mean	.414	.094	-.073	.902
One SD above mean	.001	.998	-.687	.689

*$p < .05$.

Figures

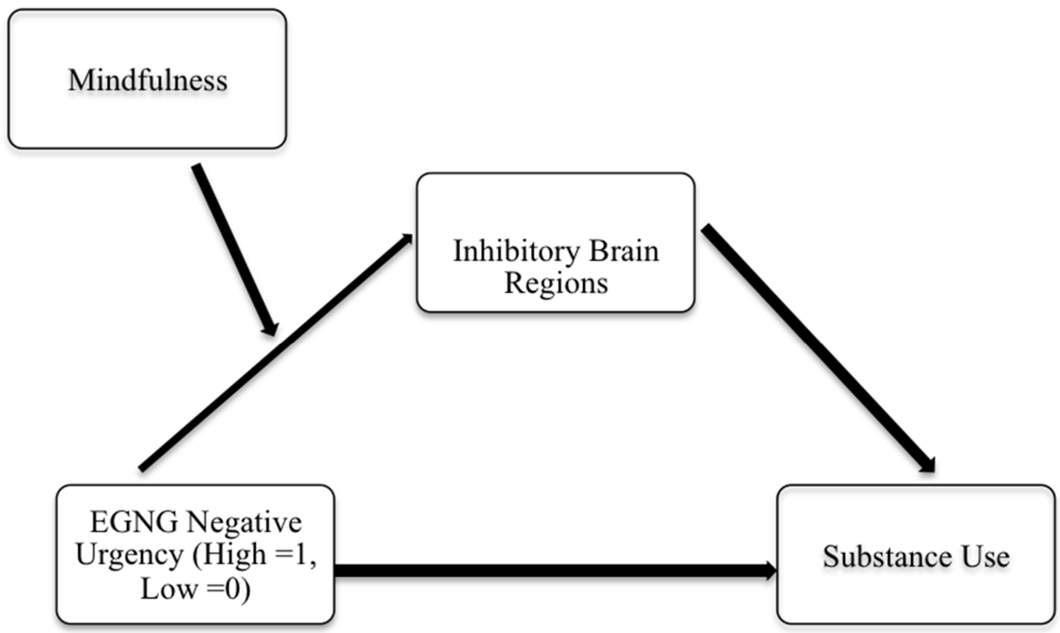

Figure 1. Model of mindfulness moderation of the mediational effects of inhibitory brain regions on the relation between negative urgency and substance use.

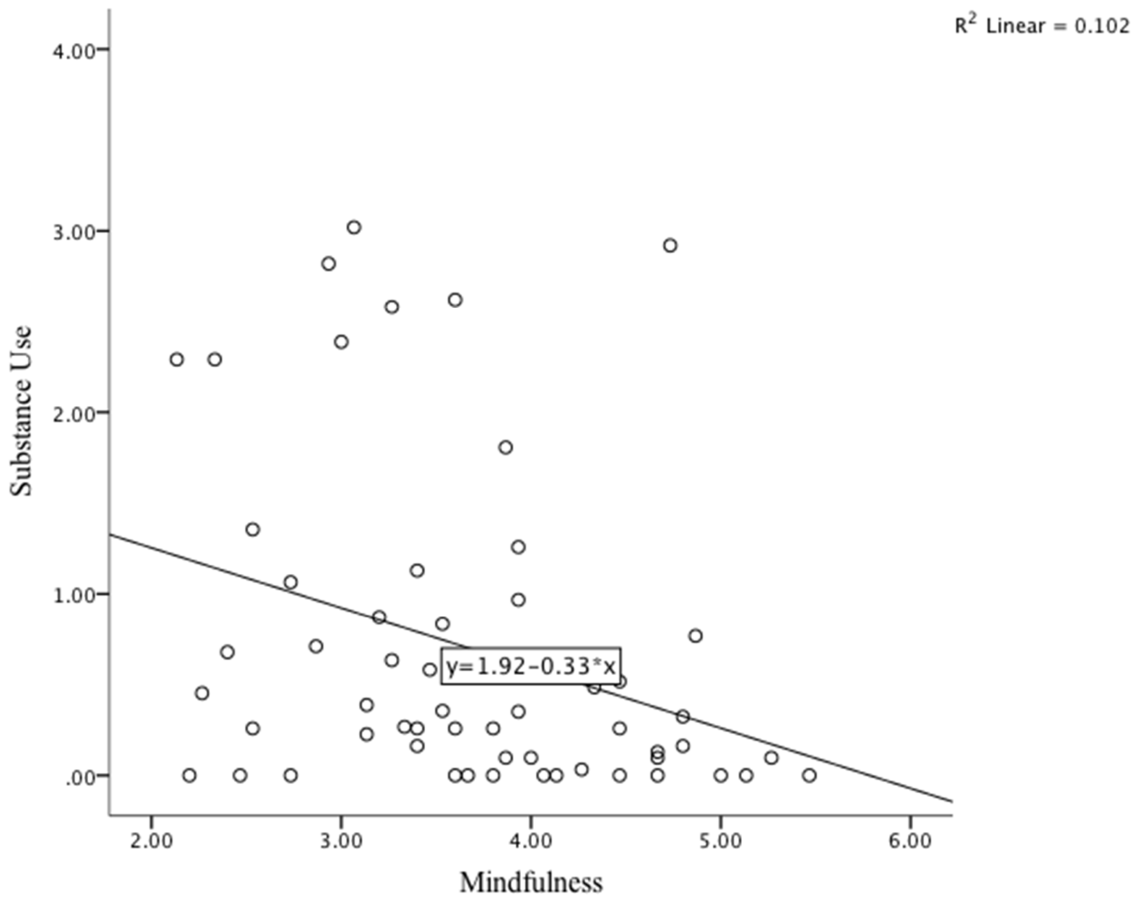

Figure 2. Scatterplot of the relation between trait mindfulness and substance use.

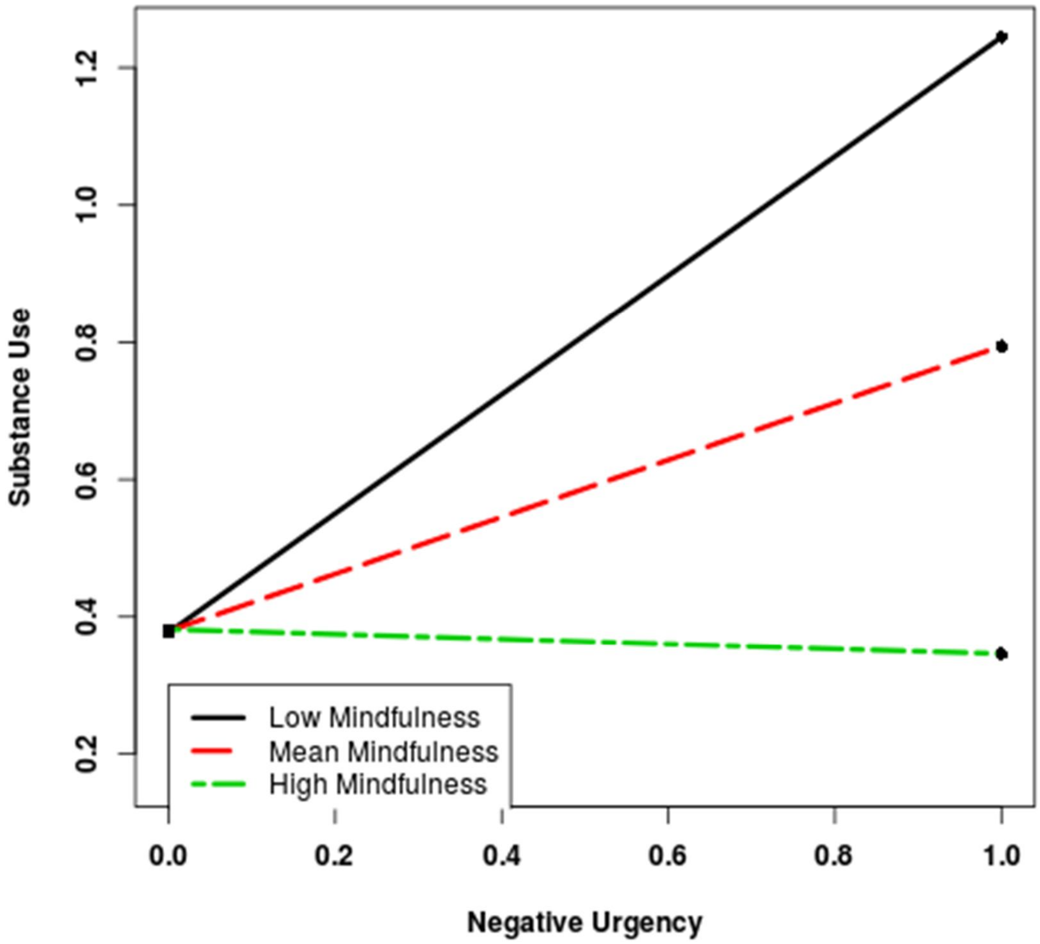

Figure 3. Simple slopes of mindfulness moderation of the relation between negative urgency and substance use.

Appendix A

Mindful Attention Awareness Scale (MAAS)

Day-to-Day Experiences

Instructions: Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what you think your experience should be. Please treat each item separately from every other item.

1	2	3	4	5	6
Almost Always	Very Frequently	Somewhat Frequently	Somewhat Infrequently	Very Infrequently	Almost Never

1. I could be experiencing some emotion and not be conscious of it until some time later.	1	2	3	4	5	6
2. I break or spill things because of carelessness, not paying attention, or thinking of something else.	1	2	3	4	5	6
3. I find it difficult to stay focused on what's happening in the present.	1	2	3	4	5	6
4. I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.	1	2	3	4	5	6
5. I tend to not notice feelings of physical tension or discomfort until they really grab my attention.	1	2	3	4	5	6
6. I forget a person's name almost as soon as I've been told it for the first time.	1	2	3	4	5	6
7. It seems I am "running on automatic," without much awareness of what I'm doing.	1	2	3	4	5	6
8. I rush through activities without being really attentive to them.	1	2	3	4	5	6
9. I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.	1	2	3	4	5	6
10. I do jobs or tasks automatically, without being aware of what I'm doing.	1	2	3	4	5	6
11. I find myself listening to someone with one ear, doing something else at the same time.	1	2	3	4	5	6
12. I drive places on "automatic pilot" and then wonder why I went there.	1	2	3	4	5	6
13. I find myself preoccupied with the future or past.	1	2	3	4	5	6
14. I find myself doing things without paying attention.	1	2	3	4	5	6
15. I snack without being aware that I'm eating.	1	2	3	4	5	6

Appendix B

Negative Urgency Subscale of

Impulsive Behavior Scale (UPPS-P)

Below are a number of statements that describe ways in which people act and think. For each statement, please indicate how much you agree or disagree with the statement. If you **Agree Strongly** circle **1**, if you **Agree Somewhat** circle **2**, if you **Disagree somewhat** circle **3**, and if you **Disagree Strongly** circle **4**. Be sure to indicate your agreement or disagreement for every statement below. Also, there are questions on the following pages.

Agree Strongly	Agree Somewhat	Disagree Somewhat	Disagree Strongly
1	2	3	4

I have trouble controlling my impulses.	1	2	3	4
I have trouble resisting my cravings (for food, cigarettes, etc.).	1	2	3	4
I often get involved in things I later wish I could get out of.	1	2	3	4
When I feel bad, I will often do things I later regret in order to make myself feel better now.	1	2	3	4
Sometimes when I feel bad, I can't seem to stop what I am doing even though it is making me feel worse.	1	2	3	4
When I am upset I often act without thinking.	1	2	3	4
When I feel rejected, I will often say things that I later regret.	1	2	3	4
It is hard for me to resist acting on my feelings.	1	2	3	4
I often make matters worse because I act without thinking when I am upset.	1	2	3	4
In the heat of an argument, I will often say things that I later regret.	1	2	3	4
I always keep my feelings under control.	1	2	3	4
Sometimes I do impulsive things that I later regret.	1	2	3	4

<u>Scoring: (Negative) Urgency</u> (all items except 1 are reversed)

items 2 (R), 7(R), 12 (R), 17 (R), 22 (R), 29 (R), 34 (R), 39 (R), 44 (R), 50 (R), 53, 58 (R)

(R) indicates the item needs to be reverse scored such 1=4, 2=3, 3=2, and 4=1.

Appendix C

Neuroticism Subscale of International Personality Item Pool

Instructions: Please respond to the follow questions on the rating scale below. Circle the response that describes you the most.

Disagree Strongly	Disagree Somewhat	Agree Somewhat	Agree Strongly
1	2	3	4

Often feel blue.	1	2	3	4
Dislike myself.	1	2	3	4
Am often down in the dumps.	1	2	3	4
Have frequent mood swings.	1	2	3	4
Panic easily.	1	2	3	4
Rarely get irritated.	1	2	3	4
Seldom feel blue.	1	2	3	4
Feel comfortable with myself.	1	2	3	4
Am not easily bothered by things.	1	2	3	4
Am very pleased with myself.	1	2	3	4

Appendix D
Alcohol Timeline Follow-back measure

Instructions for Filling Out the Timeline Alcohol Use Calendar

To help us evaluate your drinking, we need to get an idea of what your alcohol use was like in the past ____ days. To do this, we would like you to fill out the attached calendar.

- Filling out the calendar is not hard!
- Try to be as accurate as possible.
- We recognize you won't have perfect recall. That's OKAY.

WHAT TO FILL IN

- The idea is to put a number in for **each day** on the calendar.
- On days when you did not drink, you should write a "0".
- On days when you did drink, you should write in the total number of drinks you had.
- We want you to record your drinking on the calendar using Standard Drinks. *For example,* if you had 6 beers, write the number 6 for that day. If you drank two or more different kinds of alcoholic beverages in a day such as 2 beers and 3 glasses of wine, you would write the number 5 for that day.

It's important that something is written for <u>every</u> day, even if it is a "0".

YOUR BEST ESTIMATE

- We realize it isn't easy to recall things with 100% accuracy.
- If you are not sure whether you drank 7 or 11 drinks or whether you drank on a Thursday or a Friday, **give it your best guess!** What is important is that 7 or 11 drinks are very different from 1 or 2 drinks or 25 drinks. The goal is to get a sense of how frequently you drank, how much you drank, and your patterns of drinking.

HELPFUL HINTS

- If you have an appointment book you can use it to help you recall your drinking.
- Holidays such as Thanksgiving and Christmas are marked on the calendar to help you better recall your drinking. Also, think about how much you drank on personal holidays & events such as birthdays, vacations, or parties.
- If you have regular drinking patterns you can use these to help you recall your drinking. For example, you may have a daily or weekend/weekday pattern, or drink more in the

summer or on trips, or you may drink on Wednesdays after playing sports.

COMPLETING THE CALENDAR

- A blank calendar is attached. Write in the number of Standard Drinks that you had each day.
  The time period we are talking about on the calendar is **from**
  ________________________ to _______________________.
- In estimating your drinking, be as accurate as possible.
- **DOUBLE CHECK THAT <u>ALL</u> DAYS ARE FILLED IN BEFORE RETURNING THE CALENDAR.**
- Before you start look at the **SAMPLE CALENDAR AND STANDARD DRINK CHART** on the next page.

SAMPLE CALENDAR

2000	SUN	MON	TUES	WED	THURS	FRI	SAT
						1 8	2 0
S	3 7	4 Labor Day 0	5 3	6 8	7 1	8 0	9 11
E	10 2	11 2	12 0	13 3	14 5	15 14	16 4
P	17 2	18 0	19 0	20 0	21 0	22 2	23 13
T	24 0	25 0	26 6	27 0	28 0	29 0	30 2

U. S. STANDARD DRINK CONVERSION CHART

One Standard Drink Is Equal To

◆ **12 oz of BEER (5%)**

◆ **5 oz of WINE (10% – 12%)**

◆ **3 oz of FORTIFIED WINE (16% – 18%)**

◆ **1.5 oz of HARD LIQUOR (86 proof – 100 proof; 43% – 50%)**

◆ WINE: 1 Bottle

25 oz/750 ml	=	5 standard drinks
40 oz/1.5 liter	=	8 standard drinks
25 oz fortified	=	8 1/3 standard drinks

◆ HARD LIQUOR: 1 Bottle

12 oz (mickey)	=	8 standard drinks
26 oz	=	17 1/3 standard drinks
40 oz	=	26 2/3 standard drinks

Vita

Alexandra Morgan Martelli is an American citizen born on October 18th, 1990, in Decatur, Georgia. She graduated from James W. Robinson Secondary School in Fairfax, Virginia in 2009. She received a Bachelor of Science with a concentration in Psychology from George Mason University in Fairfax, Virginia in 2013.