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An Exploration of the Relationships Among Trait Mindfulness, Executive Function, and Alcohol Use

Matthew Iwaniec

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AN EXPLORATION OF THE RELATIONSHIPS AMONG TRAIT MINDFULNESS,
EXECUTIVE FUNCTION, AND ALCOHOL USE

A Dissertation

Submitted to the School of Graduate Studies and Research

in Partial Fulfillment of the

Requirements for the Degree

Doctor of Psychology

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This study examined relationships among executive function (EF), mindfulness, emotional control, impulsivity, and alcohol use in a college sample. Students ($N=155$) were administered objective performance measures in three theoretical domains of executive function. These included Switching (measured by the Wisconsin Card Sort Test and Iowa Gambling Task), Inhibition (measured by the Stroop Color-word Test, the Go/No-Go task and the Continuous Performance Task), and Updating (measured by the *N*-Back task and Digit Span task). Participants also completed the Five Facet Mindfulness Questionnaire (FFMQ), Emotion Response Questionnaire (ERQ), UPPS-P, Daily Drinking Questionnaire (DDQ-R), and Rutgers Alcohol Problem Index (RAPI).

It was predicted that better EF performance, higher levels of trait mindfulness, adaptive emotional responding, and less impulsivity would correspond with lower levels of alcohol consumption on the DDQ-R and lower levels of alcohol related problems on the RAPI. These hypotheses were partially supported. Sex, age, and the Negative Urgency and Premeditation subscales of the UPPSP predicted alcohol use. The Acting with Awareness subscale of the FFMQ and the Negative Urgency and Premeditation subscales of the UPPSP predicted alcohol related problems. Mindfulness, EF, and emotional responding did not significantly predict overall alcohol use, diminishing their utility as assessment strategies for predicting general alcohol use. However, a reciprocal relationship between the Negative Urgency and lack of

Premeditation facets of impulsivity and alcohol use and abuse was demonstrated. The use of healthy young adults in this study showed that the connection between impulsivity and alcohol abuse is not confined to those meeting clinical criteria for alcohol abuse or dependence.

Hypotheses that higher mindfulness scores would predict better adaptive emotional responding and less impulsivity were partially supported. Results showed higher trait mindfulness was predictive of less emotional suppression, but mindfulness was not predictive of emotion-based decision making or adaptive emotional reappraisal. The five mindfulness facets predicted UPPS-P Negative Urgency and UPPS-P positive urgency scores, but not UPPS-P Premeditation, Perseverance, or Sensation Seeking scores. It was also predicted that better performance on EF measures would correspond with higher levels of trait mindfulness, more adaptive emotional responding on the ERQ and better emotion-based decision making on the IGT. These hypotheses were not supported. No EF domains were significantly related to mindfulness, emotional responding, and alcohol use of alcohol related problems.

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CHAPTER I

REVIEW OF THE LITERATURE

Introduction

Rates of alcohol consumption among college students are higher than any other age cohort, with nearly 20 % meeting diagnostic criteria for abuse or dependence (Hingson, 2010) and pervasive amounts of subclinical problematic drinking occurring across a wider range of students (Babor, 2010). This rate of drinking behavior has held consistently despite clearly documented harmful risks and consequences associated with both acute and chronic alcohol abuse (SAMHSA, 2013). Research on predictive factors and effective treatments has flourished during the last two decades, resulting in expanding financial and clinical resources to address this concern, yet abuse remains commonplace (Hingson, 2010). It is known that alcohol abuse is associated with diminished attention, inhibitory control, cognitive flexibility, and decision making (Townshend & Duka, 2005), academic difficulties (Wechsler & Nelson, 2008), mental health concerns (Blanco et al., 2008), assaults (Hingson, Heeren, Winter, & Wechsler, 2005), neurotoxicity (Harper, 2007), and fatalities (Hingson, Zha & Weitzman, 2009). In an attempt to better understand corollaries and interventions associated with reduced alcohol consumption, research has consistently found that executive function and mindfulness predict treatment success and outcomes (Verdejo-García, Pérez-García, & Bechara, 2006; Murphy & MacKillop, 2011).

Executive Function (EF) is a complex domain of neuropsychological study and assessment. The construct is integrative, involving multiple distinct yet interrelated psychological abilities and neuroanatomical structures. Although there is no current consensus within the field on how to define EF, it is largely agreed that they represent higher order

cognitive processes that allow us to thrive in a complex, and ever changing environment (Jurado & Russell, 2007). Empirical efforts have been made to better define the construct, including factor analytic studies that have yielded three distinct, yet related factors: Shifting, Monitoring, and Inhibition (Miyake et al., 2000; Miyake & Friedman, 2012). These executive abilities have traditionally been associated with the prefrontal cortex (Lezak, 2012), although modern neuroimaging methods have revealed the highly integrative nature of both executive abilities and the frontal lobes (Jurado & Russell, 2007). Objective tests of EF have been used for decades to assess executive abilities; however the nature of EF requires use of multiple cognitive and somatosensory domains, making clean measurement of a “pure” construct especially challenging, and requiring integration of data from multiple sources and modalities when conducting formal evaluations of EF (Suchy, 2009). Despite these limitations, accurate assessment of EF is essential for informing clinical practice and recommendations, given the necessity of executive capacities in performing routine tasks of daily living (Lezak, 2012). Continued study is needed to better understand EF and inform better assessment practices. One strategy for addressing this challenge is to investigate other psychological constructs that demonstrate overlapping qualities, such as mindfulness.

Similar to EF, the concept of mindfulness is multifaceted, involves prefrontal cortical areas, and is without a universally accepted definition. In its most distilled form, mindfulness can be understood as purposeful attention to and awareness of present experiences with acceptance (Kabat-Zinn, 2003; Bishop et al., 2004). Recent factor analytic work on the conceptualization and assessment of mindfulness has yielded five factors: 1) Nonreactivity to Inner Experience 2) Observing Sensations/Perceptions/Thoughts/Feelings 3) Acting with Awareness 4) Describing Experiences and 5) Nonjudging of Experience. (Baer, Smith,

Hopkins, Krietemeyer & Toney, 2006). Interest in mindfulness research is currently thriving within the field of psychology (Brown, Ryan, & Creswell, 2007); however existing studies on mindfulness as a treatment strategy and wellness indicator are dogged by methodological problems, tempering any firm conclusions regarding the precise nature of mindfulness and its relationship to salutary health outcomes (Sedlmeier et al., 2012). However, biologically based imaging studies have revealed multiple similarities between mindfulness and EF including increased activity and cortical thickness in areas of the frontal lobes that have been associated with both constructs (Hölzel et al., 2011).

Both Mindfulness and EF include an observing component of conscious self-awareness of present moment experiences that can manifest in trait and state-like ways. This awareness is essential for the enactment of flexible goal-directed behavior and emotional control as it detects internal and external indications of ineffective strategies and imperiled goals. Responding to these challenges requires cognitive flexibility, an attribute which has been associated with adaptive living, wellness and resiliency (Hayes, Luoma, Bond, Masuda & Lillis, 2006). Such flexibility is one type of EF and is inherent in the mindfulness concept. The three executive abilities proposed by Miyake and colleagues (2000) also appear to be necessary precursors for the five facets of mindfulness put forth by Baer and colleagues (2006), yet no current study has examined this putative relationship. However, research has shown that attention to experiences (included in the observing, concentration, and describing facets of mindfulness) to be necessary ingredients for eliciting executive and emotional control (Bartholow, Henry, Lust, Sauls, & Wood, 2012).

The Affect Alarm Model of Self-Control (AAM) and the Somatic Marker Hypothesis (SMH) provide a theoretical framework for understanding the neural and psychological

processes that connect EF, mindfulness, and emotional control. The AAM argues for the preeminent position of emotion as a conflict cue that warns of imminent goal failures, instigating EF processes for the purpose of enacting adaptive behavioral actions. For conflict-alarm emotion to be detected it must first be observed. One way of achieving such observation is through mindful awareness and acceptance of present experiences. Similarly, the SMH posits that deficits in functional behavior are the result of an impaired ability to use emotion-based signals produced by the body (“somatic markers”) to inform behavioral responses. Emotion often has been ignored in studies of EF (Damasio, 1994); however, neuroimaging studies indicate that the neural substrates believed to mediate emotional and executive processes are highly integrated (Miller & Cohen, 2001) and that somatic emotional experiences activate executive control networks (Inzlicht, Bartholow and Hirsh, 2015). Activations of such networks are necessary for functional decision making (Damasio, 1994). Neuroimaging investigations indicate trait mindfulness is associated with increased activation of the responsive system charged with managing emotional reactivity and enabling adaptive decisions. This has direct implications for the treatment of alcohol abuse and dependence, as mindfulness interventions have been shown both to activate prefrontal decision-making centers (Creswell, Way, Eisenberger, & Lieberman, 2007) and to reduce drinking behaviors (Bowen et al., 2006).

The current psychological and neuroscience literature has documented associations among EFs, mindfulness, and alcohol use; however, the precise nature of these relationships remains unclear. It has been proposed that mindfulness results in improved emotional regulation and behavioral health outcomes via improvement of EF (Teper, Zindel, & Inzlicht, 2013), yet still no study has investigated mindfulness, EF, and alcohol abuse concurrently for the purpose of further explicating this relationship. Given the elusive nature and assessment challenges

connected to EF, further investigation of similar constructs and associated alcohol abuse can better inform assessment and clinical practices of both EF and substance abuse. The purpose of this study is to examine this putative relationship among mindfulness, EF, and the subsequent behavioral outcome of alcohol abuse. Such exploration will shed light on the theoretical underpinnings and mechanisms by which mindfulness and EF operate and influences behavior.

Executive Function

History and Definition of the Construct

Executive function (EF) represents a relatively new area of formal inquiry in psychology. Although humans across eras and cultures have long appreciated the ideas of will, control, and strategizing, grouping of such abilities for the purpose of broad scientific analysis did not occur until the second half of the twentieth century. Despite progressing advances in psychological science, the field is absent a definitive theory of executive function (Miyake et al., 2000). Although there is no current consensus within the field on how to define EFs, it is largely agreed that they represent higher order cognitive processes that allow us to thrive in a complex, and ever changing environment (Jurado & Russell, 2007).

Evolutionary theory contends that executive processes offer a great adaptive advantage by freeing an organism of unwittingly enacting innate, overlearned, or prepotent behavioral reactions (Suchy, 2009). Of all animal species, humans possess the most highly evolved executive abilities, allowing for the integration of past experience, future goals, considered options, and situational contexts, when determining an active response (Suchy, 2009). Broadly, these abilities include a wide array of interconnected, yet distinct cognitive processes that include planning, prepotent response inhibition, attentional control, attention shifting, cognitive

flexibility, self-monitoring, working memory, and the delay of reward (Tang, Yang, Leve, & Harold, 2012).

The study of executive processes has roots in neuropsychological assessments of patients who suffered injury to the frontal lobes, with the story of Phineas Gage often cited as the first and most famous of cases involving frontal lobe damage (Harlow, 1869). Gage's survival following profound brain trauma sparked public interest; however, his subsequent emotional, behavioral and social disinhibition following the tamping iron accident illuminated the biological grounding of behavior and personality. More than a century later, Luria (1967) applied methodical study to frontal brain injury among World War II veterans, first coining the "frontal lobe syndrome" to describe this constellation of disinhibited behavioral symptoms. It was Luria who first conceptualized our modern understanding of EFs in his 1973 book *The Working Brain: An Introduction to Neuropsychology*. Here, he identified the frontal lobes as essential for the holistic organization of cognitive processes, which included planning activities and monitoring performance.

Exploration of EF continued with Baddeley and Hitch (1974) and their definition of EF as a "central executive" subcomponent in their proposed model of working memory. According to Baddeley (1998) the central executive was originally included in this model as a reminder of the importance of executive ability in working memory performance, although the construct was not well defined or well understood at the time. Baddeley and colleagues later explored connections between the central executive and working memory by longitudinally observing the diminishing capacity of Alzheimer's patients to perform a digit span and tracing task simultaneously (Baddeley, Bressi, Delia Sala, Logie, & Spinnler, 1991). Originally, Alzheimer's patients were able to perform each task adequately when done in isolation, but they were not able

to switch between task demands on a simultaneous administration. This suggests that an executive component was necessary for mediating the switching function (Baddeley, Logie, Bressi, Delia Sala, & Spinnler, 1986).

Next, Norman and Shallice (1986) expounded on the central executive by incorporating it into their Supervisory Attentional System (SAS). The SAS model deconstructs EF into two basic components: automatic and controlled processes. Norman and Shallice argued that the automation of routine behaviors provided efficiency of performance for everyday tasks, whereas a more controlled executive was necessary for situations involving planning, novel sequencing, decision making, correcting errors, and overriding powerful habitual actions (Shallice and Burgess, 1991). Attempts to develop one level and two level constructs of EF, however, were seen as too simplistic by many other authors on the subject, and investigation continued (Banich, 2009).

In 1982, Lezak formally entered the inquiry by defining EF as the element of human cognition dealing with how behavior is expressed. To better operationalize the study and assessment of EF, she outlined four functional components of the construct 1) goal formation 2) planning 3) carrying out goal directed plans, and 4) effective performance. While essential for normal human social functioning and independent living, the EFs were defined as distinct from other cognitive abilities such as intelligence and perception (Lezak, 1982). This distinction was made given that individuals who have suffered great cognitive losses and cortical damage can continue relatively functional lives provided that EFs remain intact (Lezak, 2012). Despite lacking a putative agreement on what exactly EF is, contemporary conceptions of EF agree on the importance and intricacy of these abilities as allowing us to shift our mindset, formulate

plans, inhibit inappropriate behaviors, monitor progress, and persevere until task completion (Jurado & Russell, 2007).

Neuroanatomical Substrates of Executive Function

The execution of such tasks requires high levels of coordination and communication among several brain areas. The prefrontal cortex represents the most recent neural advancement of human evolution and has more associative connections to other brain regions than any other cortical area (Royall et al., 2002). As such, the field has associated executive abilities and impairments with the prefrontal cortex – a cerebral area that encompasses the frontal lobe region lying anterior to the sensorimotor strip (Lezak, 2012). Multiple neurophysiological studies of prefrontal brain regions and their activation under experimental conditions provide evidence of their involvement in differing higher-order cognitive tasks. For example, the dorsolateral prefrontal cortex (DLPC) is associated with working memory (Fuster, 2000), allowing for the temporary holding of task-relevant information. The DLPC is involved in sustained attention, response selection, and motivation (Bush et al., 1999; Seidman et al., 2006; Swards & Swards, 2003), which are all necessary abilities for successful complex task performance. The ventral prefrontal cortex (VPFC) is thought to be the neurological seat of emotional inhibition and reward sensitivity (Angrilli, Palomba, Cantagallo, Maietti, & Stegagno, 1999; Schultz, Trembaly & Hollerman, 2000), important capacities for effective social interactions, harm avoidance, and emotional control. Evidence has shown that damage to the ventromedial area of the frontal lobes may lead to impaired attention, increased distractibility, poor impulse control, and socially inappropriate behavior (Malloy, Bihle, Duffy, & Cimino, 1993). Damage to the medial prefrontal area is associated with attentional and drive deficits, with persons suffering such

damage often demonstrating little affect and (in extreme cases) absence of speech and motor activity (Manchester, Priestly & Jackson, 2004).

Despite a historically strong emphasis on the frontal lobes, it is nonetheless critical for a full understanding of executive faculties to recognize the integrative nature of the brain and its functioning. For example, working memory is also dependent on the parietal lobe, inhibition on the thalamus and basal ganglia, and sustained attention on the thalamus and multiple right hemisphere regions (Suchy, 2009). For all the neurological associations among EFs and the prefrontal cortex that have been demonstrated, additional evidence for multiple subcortical associations are also likely to be found (Aron, 2008; Tekin & Cummings, 2002).

Given this high level of integration, an area of contention within the EF research is the question of whether EF represents a singular unitary ability or a collection of interrelated, yet distinct abilities. Evidence exists for both views; however, the field appears to be heading toward an understanding of EF as a complex assortment of semi-independent functions (Jurado & Russell, 2007). In summarizing lesion research on the diversity of prefrontal correlates of behavior in primates, Teuber (1972) first questioned the extent to which different observed functions attributed to the frontal lobes could be considered unitary. Years of research on Baddeley's central executive has indicated that it cannot be exclusively mapped onto a single anatomical feature (such as the frontal lobes) nor does it resist deconstruction into several subdivisions (Baddeley & Wilson, 1988; Baddeley, 1996; Baddeley 1998; and Shallice & Burgess, 1996). A strong argument against a singular executive ability comes from a collection of research showing individuals with frontal lobe injuries are able to perform well on objective executive tests, while performing poorly on others (Godefroy, Cabaret, Petit-Chenal, Pruvo, & Rousseaux, 1999). This

variation in performance on EF measures within and between subjects suffering frontal lobe damage is found repeatedly in the literature (Royall et al., 2002)

Without question, EF is an essential and core component of everyday functioning, making it an important area of empirical study and clinical assessment. Outside a strictly neuropsychological domain, poor EF has been associated with compromised health protective behavior (Hall, Fong, Epp, & Elias, 2008) and mental health concerns (Tang et al., 2012). Examples of maladaptive behaviors and psychiatric problems include limited physical activity, unhealthy eating habits, substance abuse, ADHD, depression, and antisocial behavior. Executive impairments have been demonstrated in nearly every major psychiatric disorder, with scores on measures of EF more strongly associated with functional status, level of care, and need for service than syndrome-specific symptoms or scores on nonexecutive measures (Royall et al., 2002). More generally, the element of self-control subsumed under the EF umbrella has broad implications for life-outcomes, as shown repeatedly by Walter Mischel and subsequent researchers in administering his now famous “marshmallow test” (Mischel et al., 2010). Mischel’s longitudinal work demonstrated that young children with the ability to resist the temptation of immediate gratification (eating one marshmallow straightaway) in favor of a distal reward (eating two marshmallows later) enjoyed positive and consequential outcomes in social, cognitive and mental health domains relative to children who could not resist temptation. In short, EF is necessary for functional, independent, and healthy living across developmental phases.

Assessment of Executive Function

Not surprisingly, the subfield of clinical neuropsychology has included EF as one of the important neurocognitive domains of assessment. However the assessment of this central

construct is not without difficulty. Three major problems in this particular assessment sphere include the lack of a precise definition of EF, the fact that most current tests of EF impurely assess more than one ability, and that not all EF is precisely localized within the frontal lobes (Jurardo & Roselli, 2007). Impure assessment of EF is particularly challenging in clinical evaluations and necessitates collateral measurement of other domains that impact EF (e.g., sensory impairments, motor limitations, language difficulties, and attention deficits).

Approaches to defining the nature of EFs for the purpose of creating and utilizing assessment measures varies widely by researchers. Traditionally, given Luria's pioneering research, the field has defined EF impairments as manifestations of a "frontal-lobe syndrome." Based on Luria's notion, early tests of EF, such as the Wisconsin Card Sort (WCST) and the Trail Making Test – Part B, were used to detect such impairments and were validated on their sensitivity to frontal lobe lesions (Suchy, 2009).

Whereas other cognitive functions (e.g., intelligence, verbal abilities, processing speed, etc.) can be elicited in a formal assessment setting, the complex operation of EFs in response to novel challenges, often defies structured evaluative means (Lezak, 1982). It is very difficult, if not impossible, to gain a clear picture of an individual's true executive abilities by administering an individual standardized test because executive weakness become most apparent in situations that lack a definite structure – an enormous challenge for standardized psychometry (Suchy, 2009). By their nature, executive abilities are highly integrative, requiring input from several brain areas, and highly dependent, demanding intact abilities in other neuropsychological domains. For example, an individual may perform poorly on a test of judgment due to aphasic symptoms, or achieve an impaired score on a card sorting test due to visual deficiencies. Such ancillary domains must also be assessed and considered when conducting an integrated

evaluation of EF. Unless an individual exhibits marked cognitive deficits during an examination, even a well-trained examiner may be unable to determine that person's true level of capacity to function outside a clinical office (Lezak, 1982). Empirical studies have demonstrated a weak to moderate relationship between executive test performance and routine behavior (Manchester, Priestly & Jackson, 2004). Therefore, current practice includes the administration of several objective and subjective measures of EF. By this method, assessors hope to garner enough evidence to deduce an ecologically valid diagnosis of an individual's current executive capacities. Currently, there is no "gold standard" EF test or assessment battery (Royall et. al, 2002).

In an effort to further explicate EF and address the impurity problem of EF assessment, Miyake and colleagues (2000) investigated the organization and roles among performances on several extant measures purported to measure different executive abilities. The postulated components of EF examined by Miyake and colleagues were garnered from existing EF literature and included: shifting of mental sets ("Shifting"), monitoring and updating of working memory representations ("Monitoring"), and inhibition of prepotent responses ("Inhibition"). Latent variable analysis of task performance scores yielded three distinctly separable yet moderately correlated factors. Consistent with the integrated nature of the brain, these results lend support to a theory of EF that respects both the unity and diversity of these abilities. However, one considerable limitation of this study included the use of a healthy, young adult sample and a finite number of executive tests. The author's noteworthy findings spawned additional studies of an emerging theoretical framework of EF as separate abilities.

Latzman and Markon (2010) investigated the factor structure and relationships among the subtests of the Delis-Kaplan Executive Function System (D-KEFS). The D-KEFS is

standardized measure of EF composed of nine examiner administered subtests meant to assess attention, lexical fluency, visual fluency, behavioral inhibition, conceptual flexibility, strategic thinking deductive reasoning, forward planning, and abstraction abilities (Delis, Kaplan, & Kramer, 2001). Consistent with Miyake's work, Latzman and Markon confirmed a three factor structure using both the existing norming sample of the D-KEFS and an independent sample of healthy adolescent males, lending credence to an emerging body of research that posits three related but distinct EFs. To date, this three factor structure has also been found in more diverse samples of adults (Fisk & Sharp, 2004), children (Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003), older adults (Hull, Martin, Beier, Lane & Hamilton, 2008), and college students (Meil et al., 2016). Important for the validity and utility of this purported EF structure, Latzman and Markon's data analysis revealed that the structure is predominantly stable across age, although other work shows this structure appears to weaken and become less differentiated with advancing age (Hull et al., 2008). The young adult sample used by Miyake may represent an age segment that best highlights the three factor structure.

Summary

The theoretical construct of EF is complicated and integrative by nature, involving multiple distinct yet interrelated psychological abilities and neuroanatomical structures. This complexity has thwarted a consensus on exactly how EF should be understood and defined and has presented unique assessment challenges. Objective tests of EF, administered under standardized conditions, often fail to measure an individual's true EF abilities as they operate in an individual's living environment outside a clinical setting. This is because general cognitive capacities, sensory motor abilities, and multiple types of EFs are needed and utilized to solve novel tasks in unfamiliar situations. Because of this complexity, modern scientific methods have

only been applied to investigations of EF relatively recently, leaving much knowledge still to be acquired and assimilated. It is known that executive abilities are essential for adaptive living. Despite limitations to the field's current understanding of EF, accurate evaluation remains indispensable for informing clinical practice and recommendations. This is especially relevant given the documented affiliation of EF with multiple mental health concerns and neuroanatomical abnormalities. A continued exploration of these associations may yield insight both into the underlying character of EF and inform better assessment practices. This can be accomplished in part by investigating alternative psychological constructs that appear to overlap with aspects of EF.

Mindfulness

History and Definition of the Construct

Despite flourishing interest in mindfulness within current psychology, settling upon an exact definition of the term presents a difficult enterprise. The practice, cultivation, and study of mindfulness began in the Buddhist tradition and has thrived there for millennia, with substantial Western scientific interest only entering the arena in later half of the last century. To elucidate what has been meant by mindfulness in Buddhist texts several authors have offered well considered interpretations (e.g. Bodhi, 2011; Dreyfus, 2011, & Dunne, 2011). Although an in-depth analysis of a Buddhist understanding of mindfulness is beyond the scope of this review, it is important to make a distinction between the classical Buddhist understanding and the contemporary psychological conception. Buddhism is an ancient and diverse religion, encompassing competing philosophical schools that view mindfulness differently, therefore it cannot be said that there is any definitive Buddhist view of the construct (Dreyfus, 2011).

Further, what is defined as mindfulness in empirical research is not necessarily what is meant by mindfulness in the Buddhist scriptural canon.

For the purpose of the modern literature, a separation from discursive thought is considered a key element of mindfulness (Quaglia, Lindsay & Goodman, 2014). To this end, many investigators have relied upon the operational definition fashioned by Jon Kabat-Zinn. A leading scholar in the mindfulness field, Kabat-Zinn spurred the popularity of mindfulness for therapeutic purposes in 1979 through the introduction of his Mindfulness Based Stress Reduction (MBSR) program at the Stress Reduction Clinic at the University of Massachusetts (Gethin, 2011). Kabat-Zinn defines mindfulness as “the awareness that emerges through paying attention, on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment to moment” (2003, p. 145). Bishop et al. (2004) further codified the use of this definition by offering a consensus paper on the definition of mindfulness. Per Bishop and colleagues, mindfulness is “self-regulation of attention so that it is maintained on immediate experience, thereby allowing for increased recognition of mental events in the present moment” and “adopting a particular orientation toward one’s experience that is characterized by curiosity, openness, and acceptance” (p. 232). The second part of this definition captures an essential emotional or intentional attitude of mindfulness in clinical settings. Therefore, in its most basic and heuristic form, mindfulness can be understood as consisting of three parts (1) awareness (2) of present experiences with (3) acceptance.

Prior to the rise of Kabat-Zinn’s influence, the Buddhist meditation teacher and writer Nyanaponika (1962) defined mindfulness as “attention” or a basic cognitive function required to perceive any object of observation. A common misconception is that mindfulness is a practice in which the mind is somehow emptied of all thoughts and emotions, conjuring images of a stoic

figure who transcends physical stimuli and petty concerns. Nyanaponika rejected the idea of mindfulness as a mystical state understood only by Buddhist sages, thereby rendering the concept more accessible to Western readers. Through Nyanaponika's understanding of ancient Buddhist texts and Buddhist meditation instruction, modern Western interest in mindfulness began to grow. It was Nyanaponika who first effectively promoted the term "mindfulness" (Gethin, 2011). In his use of the word "attention," Nyanaponika meant turning toward an object of observation, a plain and basic attention, free of confounding preconceptions, judgments and analysis. This attention was understood to be present in all acts of awareness (Gethin, 2011). Without attention, there could be no bringing to mind of current experience, whether physical, cognitive, or affective. Attention was thought to be the seed of mindfulness (Gethin, 2011). It was Nyanaponika's concept of mindfulness as bare attention, extracted from Buddhist scripture and religious practice, which has influenced contemporary scientific definitions and understanding (Gethin, 2011).

The definitions of mindfulness put forth by Kabat-Zin and Bishop represent a state orientation toward the construct, meaning that mindfulness is a particular cognitive status that can be in effect or absent at any given time. Here, mindfulness is defined as a state of consciousness characterized by a purposeful attention to present moment internal (cognitive, emotional, proprioceptive) and external (physical and environmental) experiences without evaluation or judgment. By this process mindfulness has been secularized and transformed into a technique that can be trained, practiced, and strengthened. Lines of research have emerged examining the state nature of mindfulness (Brown & Ryan, 2003; Lau et al., 2006); however, most empirical evaluations have examined the dispositional, or trait, nature of mindfulness.

Psychometric tools require reliability for predicative validity and practical utility; therefore a better understanding of mindfulness as a trait has major implications for effective assessment of the construct. From research regarding a trait perspective, capacity for mindfulness is seen as a relatively stable individual characteristic that varies within the population. Similar to other personality traits, and in accordance with trait theory, the mindfulness trait is characterized by a pattern of thoughts, emotions, and behaviors across time. Mindfulness can then be considered a habitual practice of being in a state of mindful awareness that varies in frequency, duration, and intensity among individuals (Brown et al, 2007; Brown & Cordon, 2009; Glomb, Duffy, Bono & Yang, 2011). Among clinically relevant variables, trait mindfulness measures have been shown to predict trait anxiety (Walsh et al., 2009), depressive symptoms (Way, Creswell, Eisenberger, & Lieberman, 2010), gambling behavior (Lakey, Campbell, Brown & Goodie., 2007), alcohol cue reactivity (Garland, 2015), and dorsomedial prefrontal cortex and amygdala responses (Frewen et al., 2010).

The past decade has witnessed an expanding empirical interest in the concept of mindfulness, evidenced by a proliferation of research with each passing year. In 1990 the number of mindfulness related reports was less than 80 (Brown, Ryan & Creswell, 2007), whereas a simple internet search in 2014 yields over 10,000 scholarly reports for the current year alone. Implications of mindfulness as a trait and a practice have been examined in multiple subfields of modern psychology, with particular interest paid by the applied disciplines. For example, several meta-analyses of this growing research body exploring health-related outcomes have documented the utility of mindfulness practice and therapies for producing improved physical and mental health effects (Chiesa & Serretti, 2011; Khoury et al., 2013; Mars & Abbey, 2010; Piet & Hougaard, 2011). A meta-analysis by Hofmann, Sawyer, Witt and Oh (2010)

found robust effect sizes for mindfulness-based interventions when treating anxiety and mood symptoms in clinical samples, two of the most common disorders encountered in epidemiological surveys (Baumeister & Härter, 2007).

Assessment of Mindfulness

Clinical psychology's burgeoning interest in mindfulness has produced a variety of self-report measures that attempt to define and measure the construct. With the emergence of multiple psychometric scales, the possibility emerged to study the relationships among these separate works, better elucidating both an understanding of the construct itself and how it is measured. Work by Baer and colleagues (2006) explored the underlying factorial structure of existing measures of mindfulness including the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), the Freiburg Mindfulness Inventory (FMI; Walach, Buchheld, Büttenmüller, Kleinknecht, & Schmidt, 2006), the Kentucky Inventory of Mindfulness Skills (KIMS; Baer, Smith, & Allen, 2004), the Cognitive and Affective Mindfulness Scale (CAMS; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007), and the Mindfulness Questionnaire (MQ; Chadwick et al., 2008). Exploratory and Confirmatory factor analysis of these measures revealed five facets: 1) Nonreactivity to Inner Experience 2) Observing/Noticing/Attending to Sensations/Perceptions/Thoughts/Feelings 3) Acting with Awareness/Automatic Pilot/Concentration/Nondistracted 4) Describing/Labeling with Words 5) Nonjudging of Experience. Because these factors were derived from self-report measures built by modern psychologists, they are a distillation of empirical attempts to operationalize and quantify mindfulness. These five facets represent the essential components of mindfulness as current psychology defines it, yet the relationships among these factors and practical life matters of mental and physical health is not quite clear.

Biological and Psychological Mechanisms of Mindfulness Effects

To clarify the theoretical mechanisms of action for the way in which mindfulness works, Hölzel and colleagues (2011) used existing research to propose essential components of mindfulness meditation. These include elements that appear in literature on executive and emotional control, primarily attention regulation, body awareness, and emotional regulation. A common point of entry for mindfulness practitioners is focused attention meditation, in which one is instructed to focus attention of awareness of the physical sensations of the breath, returning attention to the breath whenever the individual has noticed the mind wondering elsewhere. The combination of purposeful attention and a nonjudgmental stance results in decentering, or the ability to observe thoughts and feelings as transient and objective mental experiences rather than reflections that represent truth (Fresco et al., 2007). Both self-report and empirical studies have documented improvements in sustained attentional performance with practice (Barinaga, 2003; Van den Hurk, Gionni, Gielen, Speckens, & Barendregt, 2010). This can be understood as a function of increased activity (Hölzel et al., 2011; Gard et al., 2012; Tang et al., 2010), cortical thickness (Grant, Courtemance, Duerden, Duncan & Rainville, 2010), and white matter connectivity (Tang et al., 2010) within the anterior cingulate cortex (ACC) among individuals trained in mindfulness attention.

Body awareness and accuracy of interoceptive interpretations are associated with the insula and somatosensory cortical areas (Craig, 2003; Critchley, Wiens, Rotshtein, Ohman & Dohlan, 2004). Individuals receiving training in mindfulness demonstrate increased cortical activation of the insula and secondary somatosensory structures when focusing on present experiences (Farb et al., 2007), when presented with sadness eliciting stimuli (Farb et al., 2010), and when exposed to emotionally distressing stimuli (Gard et al., 2012). This heightened processing is

hypothesized to correlate with subjective experiences of the stimuli that more accurately reflect the true nature of the stimuli and may therefore be helpful in treating psychological dysfunctions (Hölzel et al., 2011).

Neuroscientific studies have also demonstrated that improved emotional control is associated with mindfulness. Higher levels of trait mindfulness are associated with increased ventromedial and ventrolateral prefrontal cortical activity, attenuated amygdala activity, and stronger inhibitory connections between the PFC and the amygdala (Creswell et al. 2007). These changes appear to be amenable to mindfulness training as well. Following mindfulness exercise, increases in ventrolateral PFC activity (Farb et al., 2007) and more efficient inhibition of amygdala activity (Goldin & Gross, 2010) have been documented.

Despite evidence that mindfulness is related to well-being and positive clinical outcomes, existing research has not yet demonstrated conclusively that mindfulness itself mediates these outcomes. Rather, given our current understanding, mindfulness and any positive clinical results are presently best considered co-emergent phenomena (Chambers, Gullone & Allen, 2009). It has been argued that the concept of mindfulness may have become so popular because it simply represent be a transtheoretical process of change that is common to all forms of successful psychotherapy. For effective change to occur, the client must achieve an awareness of emotional experience and the ability to tolerate aversive experiences while enacting more adaptive behavioral strategies. Siegel, Germer, and Olendzki (2009) have argued that this process is at work whether conceptualized in interpersonal, psychodynamic, cognitive, behavioral, or humanistic frameworks.

From a specifically cognitive-behavioral standpoint, however, the metacognitive awareness cultivated by a mindful state of consciousness creates insight that thoughts are not

facts, thereby helping depressed people disentangle from depressive ruminations (Teasdale et al., 2002). Acquiring awareness of emotional experiences and insight into their impact on behavior responses allows people to intentionally respond in healthy ways and achieve positive outcomes. Thus, mindfulness is an antecedent-focused type of regulation that works by changing a person's relationship to his or her emotions (Gross & Thompson, 2007). The present moment focus of mindfulness deploys attention to immediate sensory experiences, bringing distressing emotions and cognitions into conscious awareness and creating distance between the subjective experience of the emotion and its cognitive appraisal. Mindful acceptance of distressing emotions encourages a nonjudgmental attitude and mitigates the need for cognitive rumination or emotional suppression (Teper et al., 2013). Therefore, mindfulness does not reduce troubling affective reactions themselves, but aids in attenuating the negative consequences of their repeated activation over time (Williams, 2010).

Because this particular avenue of research has grown rapidly in a relatively short period of time, shortcomings exist within the body of literature. A recent meta-analysis of the effects of meditation (one traditional mindfulness practice) by Sedlmeier and colleagues (2012) excluded 75 percent of its original sample due to methodological problems, including lack of a control group, short-term interventions, unreported small samples sizes, and insufficient theoretical bases for interventions. Similarly, a review by Chiesa and Serretti (2011) found that the mindfulness literature contains considerable heterogeneity in the types of mindfulness practices and interventions utilized under the general heading of mindfulness research.

Summary

Mindfulness is an ancient concept rooted in Buddhist meditative practices. Similar to EF the nature of mindfulness appears to be complex and multifaceted, involves multiple frontal

cortical areas, and eludes a universally accepted definition. Although interest and literature on mindfulness is currently prolific, modern Western science has just begun to investigate mindfulness as a psychological construct that can be measured and studied. Much of the existing literature on mindfulness and health related outcomes contains substantial variance in the use of measures, interventions, and definitions of mindfulness, thus warranting an improved theoretical understanding of the construct and its relationship to observed outcomes. Given that contemporary neuroimaging studies of mindfulness reveal increased activity and cortical thickness in areas of the frontal lobes associated with EF and emotional control, primarily the ventromedial prefrontal cortex, ventrolateral prefrontal cortex, and the ACC, a logical next step is a study of the relationships among mindfulness, EF, and subsequent behavioral outcomes. Such exploration will shed light on the theoretical underpinnings and mechanisms by which mindfulness operates and influences behavior.

Executive Function and Mindfulness

Rationale for Association

Both Mindfulness and EF have trait-like features. Trait based mindfulness can be thought of as an enduring characteristic of personality, in that an individual can frequently act with awareness of present focused experience while reserving judgment and reactivity. However, to consistently enact a state of mindfulness in all interactions and at all times is impossible as humans are subject to ever changing emotions and cognitions. Altered states of consciousness including day-dreaming, hypnosis, and sleep, are among the mundane occurrences experienced on a frequent basis that exist outside the parameters of a mindful state of awareness. Despite the existence of multiple states of consciousness, mindfulness can also be understood as a trait or disposition by examining the frequency of mindfulness states across situations and time

(Quaglia, Brown, Lindsay, Creswell & Goodman, 2014). Research has demonstrated that individuals inherently vary on this trait within the general population and can increase dispositional levels of mindfulness with training (Brown, Ryan, Loverich, Biegel, & West, 2011). This is bolstered by findings that most measures of mindfulness, including the FFMQ, are designed for use in populations having no prior mindfulness training. Despite a lack of training in these populations, mindfulness measures yield associations with outcomes of mindfulness training, such as acceptance, kindness, and empathy (Brown, Ryan, Loverich, Biegel, & West, 2011).

Similar to mindfulness, EF can be conceptualized as a trait that varies among and within all individuals. Although EFs develop sequentially from infancy through early adulthood (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001) and are the first cognitive abilities to decline in later life (De Luca et al., 2003), EFs show trait variability among individuals within the same cohort and trait consistency within individuals measured across time. Differences in EF have been shown to discriminate between children meeting criteria for ADHD (Barkley, 1997) and at increased risk for substance abuse (Giancola & Tarter, 1999). A longitudinal study of adolescent males with ADHD over seven years revealed that most participants maintained poor performance on multiple measures of EF across 10 years (Biederman et al., 2007). Similarly, work by Tarter and colleagues (2003) on neurobehavioral disinhibition (which includes EF as a neurocognitive indicator of a larger latent construct) has shown consistency in performance on several EF measures from preadolescence through early adulthood. This neurobehavioral disinhibition construct, which includes cognitive EF, affect dysregulation, and behavioral control, has been shown to predict transition to substance abuse disorders (SUDs) in early adulthood with 90% accuracy when combined with measures of recent substance use

(Tarter et al., 2003). Also, the importance of EF as a trait is highlighted by the finding that the neurobehavioral disinhibition trait was a stronger predictor of SUDs across time than consumption of alcohol and other drugs (Tarter et al., 2003). Considering heritability, a multivariate twin study of EF (Friedman, Miyake, Young, DeFries, Corley, & Hewitt, 2008) indicated that EFs are influenced by a highly heritable common factor and additional genetic influences for specific components of EF. Given these findings, the authors concluded that EF represents one of the most heritable psychological traits (Friedman et al., 2008)

Mindfulness-based interventions that focus on increasing present moment awareness of cognitions, emotions, and behaviors have been shown to improve specific aspects of EF, including attentional and emotional control. Biologically, this is thought to occur by improving neurological operations within the ACC (Tang et al., 2012). Mindfulness based interventions include a collection of techniques designed to orient the individual toward an awareness and understanding of the integrated relationship between the mind and body. At its core is a fundamentally monistic philosophy and practice that integrates psychological and somatic experiences, processes, and abilities. Examples of such techniques include meditation, awareness of breathing, biofeedback, body relaxation, and mental imagery. As with EF, mindfulness is an integrative process, involving different brain regions for channeling and combining information to foster flexible use of strategies and skills.

The theory of EF as including abilities for planning, overlearned response inhibition, persistence, and cognitive flexibility overlaps with the construct of psychological flexibility recently discussed in the clinical cognitive behavioral literature. Within that body of research, psychological flexibility has been conceptualized as a transcendent process involving connecting with present moment experiences (without judgment and avoidance) and regulating behavior to

meet long-term desired goals (Hayes, Luoma, Bond, Masuda & Lillis, 2006). Psychological flexibility allows an individual to experience the present reality, whatever the circumstances, and choose a strategic course of action despite aversive affective, cognitive, or behavioral interference. The concept of psychological flexibility proposed by Hayes and colleagues (2006) in their model of Acceptance and Commitment Therapy (ACT) contends that psychological well-being is achieved through open contact with the internal and external environments and subsequent commitment to values-driven behavior.

Psychological flexibility, consistent with classic conceptualizations of EF, uses information and experience to free people of their perseverative and problematic behavioral patterns. Essentially, the psychological flexibility acquired through mindfulness interventions can create a gap between habitual reactions and subsequent behavioral responses. Consequently, the ACT model views many types of psychopathology as stemming from psychological rigidity. This rigidity is discernable by the overuse of ineffective regulatory attempts to avoid unpleasant experiences, without contingency-sensitive and values-consistent behavioral action. For example, an individual may repeatedly consume alcohol to avoid anxiety, despite major damage to other life domains (i.e. family, work, finances). Using this process-centered conceptualization of psychological flexibility in the ACT model, this alcohol abuse is seen as a function of experiential avoidance and habitual behavior, rather than merely an inherently destructive or morally sinful act. Mounting empirical evidence supports a positive association between psychological flexibility and psychological wellbeing (Kashdan & Rottenberg, 2010). Moreover, strong negative relationships have been found between psychological flexibility and anxiety (Tull, Salters, Roemer, 2004), chronic pain (McCracken & Velleman, 2010; Wicksell, Olsson, & Hayes, 2010), and general distress (Kashdan, Barrios, Forsyth, & Steger, 2006).

Theorists have linked psychological flexibility and mindfulness as related, but distinct constructs (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Masuda & Tully, 2012). In response to a challenge, executive abilities and psychological flexibility allow us to create a plan, initiate its execution, monitor progress, make necessary changes, and persevere until a task is completed. Whereas mindfulness is currently understood to contain five facets (nonreactivity, observing, concentration, describing, and nonjudgment) a contemporary model of executive control distills the list of known and measurable executive capabilities into three basic components: set shifting, information monitoring, and behavioral inhibition (Teper et al., 2013). It can be logically inferred that these three basic executive abilities are necessary for the five facets of mindfulness to be performed successfully. Nonreactivity and nonjudgment require the inhibition or augmentation of automatic responses and observing, concentration, and describing require monitoring and set shifting capabilities. Accumulating evidence is beginning to support a connection between mindfulness and individual components of executive control, including improvements in attentional control (Moore & Malinowski, 2009) working memory (Chambers, Lo & Allen, 2008) and behavioral inhibition (Teper & Inzlicht, 2013).

Foremost, attention to experience is essential for executive control. The term “attention” is often understood and described in terms of external, physical stimuli (e.g. attention to visual or auditory information present in the environment); however, attention can also be directed toward internal cognitive and emotional experiences. Transient pings of emotional sensation are essential for executive control, as these emotional data provide the context for the aversive or appetitive stimuli that inform behavioral responses. Empirical studies suggest tools serving to dampen affect, such as anxiolytic agents, can decrease neurological measure of executive control (Bartholow, Henry, Lust, Sauls, & Wood, 2012). In essence, one must feel the aversive affect

associated with current behavior and future goal dissonance in order to elicit control behaviors. Control is prompted by a psychological process that compares current behavior with an ultimate goal; when conflict monitoring detects that present behaviors are incongruent with mental representation of intended outcomes, control is necessary to adapt to goal demands (Botvinick, Braver, Barch, Carter & Cohen, 2001).

Mindfulness is relevant to the process of executive control and goal attainment because it is the act of consciously monitoring present behaviors and sensations and refocusing when the mind has wandered (Teper et al., 2013). Mindfulness promotes openness and sensitivity to slight changes in emotional states (Goldin & Gross, 2010) that signal the need for executive modulation and aid its action (Teper et al., 2013). A mindful individual monitors behaviors and emotions without judgment and elaboration, flexibly and adaptively redirecting the mind back on course when the stream of consciousness takes the mind off track. Mindfulness heightens immediate visceral sensations, in that it is a purposeful direction of attention to such experiences (Williams, 2010). Teper, Segal, and Inzlicht (2013) found that experienced meditators showed an amplified neuroaffective brain response to their errors on a Stroop task. It was hypothesized by the authors that the openness to errors and the negative affective state caused by errors actually facilitated control. Avoidance or stifling of unpleasant affective experiences via chemical or behavioral means diminishes our ability to exert executive control and is theorized by third-wave cognitive behavioral writers (e.g., Hayes, Strosahl, & Wilson, 1999; Linehan, Schmidt, Dimeff, Craft, Kanter, & Comtois, 1991) to contribute to psychopathology and suffering.

Summary

Both Mindfulness and EF have trait and state-like features and include an observing metacognitive aspect of the self that is capable of present moment awareness. This awareness is essential for the enactment of flexible, goal-direct behavior and emotional control.

Psychopathology of mood, behavior, and EF involve a dysfunction of the flexibility with subsequent demonstration of rigid, random, or perseverative behaviors. Whereas both mindfulness and EF are multifaceted constructs, the three executive abilities proposed by Miyake and colleagues (2000) appear to be necessary precursors for the five facets of mindfulness put forth by Baer and colleagues (2006). Attention to internal and external experiences, included in the observing, concentration, and describing facets of mindfulness, is especially important for instigating executive and emotional control, as stimuli must first be detected before control processes can commence.

The Affect Alarm Model of Self-Control

Executive Function and Mindfulness

The Affect Alarm Model of Self-Control provides a theoretical framework for conceptualizing a potential relationship between mindfulness and EF by highlighting the function of emotion in both constructs. There is an affective component of EF that is often not discussed or ignored in work investigating executive processes. For example, though intended to be a comprehensive test of EF, the D-KEFS has no measure of emotional control. This may be because traditional theories of will, self-control, and EF have generally marginalized the role of emotion, often even casting emotion as the antithesis of rational self-management. In both academic circles and broad Western culture, emotion has been viewed as the enemy of reason, with logic signifying civilized humanity and passion representing primitive instinct (Damasio,

1994). Despite past dualistic ideas of emotion and logic as opposites, modern psychology has recognized the highly integrative nature of both concrete neural networks and abstract psychological phenomenon. There is no clear demarcation in the human brain between EF and emotional processes. The frontal lobes are thought to mediate executive abilities and the amygdala is considered to be the seat of emotion, but numerous neural associations exist between the prefrontal cortex and the brain structures related to emotional experiences (Miller & Cohen, 2001). This new understanding has allowed for the concept that emotion is not the enemy of reason, but may be a pivotal ingredient for the operation of higher-order cognitive abilities such as EF.

Like other complex psychological concepts, a precise definition of emotion is somewhat elusive. Emotion can be understood as a system of “neural circuits (that are at least partially dedicated), response systems, and a feeling state/process that motivates and organizes cognition and action” (Izard, 2010, p. 367). Multiple lines of inquiry have been applied to further expound on this basic definition, ranging from basic emotion approaches to social constructionist views. However, three key themes emerge when integrating theoretical findings throughout the emotion literature (Gross & Barrett, 2011).

As outlined by Gross (2015), emotions first involve changes to physiology, behavior and subjective experience. Emotions comprise a powerful subjective experience or feeling, dispositions to act in certain ways, and elicit autonomic neuroendocrine and metabolic support for responsive action. Second, emotions develop over time, unfolding over a period of fractions of a second to minutes. This development begins with psychologically relevant situation, with subsequent attention to and appraisal of the situation resulting in a response (Barrett, Ochsner, & Gross, 2007). Third, emotions can be either helpful or harmful. Emotions prepare us to respond

to demands of the environment (Frijda, 1988) and orient us to environmental cues that help provide for important needs (Bradley, 2009). From an evolutionary perspective, emotions are generally adaptive, granting us a survival advantage by providing rapid and efficient “best guesses” of what to do in situations that recur throughout human evolutionary history. To use examples provided by Gross in his review, fear can quickly result in escape from environmental dangers, happiness reinforces helpful social relationships, and anger motivates self-protective actions.

In the Affect Alarm Model of Self-Control (AAM), Inzlicht, Bartholow and Hirsh (2015) argue for the preeminent position of emotion as a vital component of executive control. Assuming control cannot be implemented and exercised without an initial cause and signal for its implementation, the AAM posits that executive control is initiated by conflict. This conflict is defined as a competition between two or more dominant response tendencies, mental representations, or observable behaviors (Festinger, 1957; Stroebe et al., 2008). Following cybernetic principles (Weiner, 1948; Carver & Scheier, 1990) and evidence from cognitive psychological research (Botvinick et al., 2001; Holroyd & Coles, 2002), this process begins with a standard or set-point that the organism is motivated to maintain. This standard could be a simple biological homeostatic state (e.g. keeping warm), or a more complex environmental consideration (e.g. maintaining social status). Through a series of feedback mechanisms, the organism monitors the present state of affairs to detect current conflicts with these standards. If a conflict is present, an aversive affective experience is elicited, steeped in the emotional feeling of anxiety (Gray & McNaughton, 2000). Such aversive affect is necessary for self-control, as it orients the organism to the conflict, creating a sense of urgency and motivation and initiating

instrumental behavioral responses to resolve it (Inzlicht, Legault, & Teper, 2014). From this perspective, the experience of emotional distress informs an individual that a goal is at risk.

Attention to distress is required to spur action because without initial awareness the indication that a goal is in danger goes undetected. Conscious awareness of affective states and changes in subjective experience are not required for them to occur (Wingkielman & Berridge, 2004), but these changes must be perceived by monitoring systems to activate executive control responses and produce purposeful behavior. Emotional experiences capture attention because they usually signify stimuli, events, situations, and representations that are motivationally salient to the organism (Brefczynski-Lewis Hajcak et al., 2012). Cybernetic models emphasize the emotional distress caused by conflict as the pivot point in a feedback loop that instigates control pathways (Carver & Scheier, 1981). These feedback loops function for the purpose of reducing the distress via instrumental action to resolve goal conflicts. Conceptualizing distress as an indicator of threat, the reduction of distress through functional behavioral responses is generally adaptive and increases survivability. However, adaptive behavioral responses can only be initiated if individuals are sensitive to the occurrence of distress and are open to perceiving it.

Because conflict is aversive it provokes strong avoidance urges and tendencies, as all organisms are motivated to evade pain. This can be adaptive for averting existential threats or can be problematic when denying the reality of problems. According to the AAM, avoiding or ignoring signals of distress interferes with monitoring of goal conflicts and subsequent activation of executive control processes (Inzlicht et al., 2013). Similarly, self-criticism can provoke an aversive state of distress that people are motivated to escape, leading to avoidance behavior and difficulties with self-control. In contrast, a nonjudgement stance counters rumination, fantasy, and suppression by focusing attention away from secondary cognitive cascades and toward

primary somatic experiences (Brefczynski-Lewis Hajcak, Weinberg, MacNamara, & Foti, 2012). Acceptance, or open and nonjudgmental recognition of errors, enables people to attend to these errors without defensiveness or distraction, effectively improving executive control performance (Inzlicht, Legault, & Teper, 2014). Neuropsychological research supports this conceptualization. The increased acceptance of thoughts and emotions can increase goal conflict monitoring as measured by brain-based increases in error-related negativity (ERN; an event related brain potential) amplitudes (Legault, Al-Khinidi, & Inzlicht, 2012; Moser, Schroder, Heeter, Moran, & Lee, 2011) and improves performance on the Stroop task (Teper & Inzlicht, 2013).

Conceptually, use of appetitive chemical substances that function to reduce the subjective experience of distress – whether they be prescription pharmaceuticals (e.g. Xanax) or recreational drugs (e.g. alcohol) – serve to derail the cybernetic feedback loop and neurochemical cascade that instigate self-control. This can be understood at neurological, psychological and behavioral levels. Anxiolytic agents work by impacting neural substrates associated with conflict monitoring, anxious distress, and self-control, including the anterior cingulate cortex and the locus coeruleous-norepinephrine system (Gray & McNaughton, 2000). Similarly, alcohol consumed in moderate doses has been shown to depress ERN amplitudes and subsequently impairs adaptive behavioral adjustments following error commissions on the Stroop task (Ridderinkhof et al., 2002). In the broader ecological sphere, research has demonstrated a reduced occurrence of alcoholism among adolescents showing amplified ERNs during conflict inducing tasks, suggesting individuals who can monitor goal conflicts successfully demonstrate better behavioral inhibition (Smith & Mattick, 2013).

This need for both awareness and acceptance of dynamic changes in physiological and psychological states to instigate EF control directly parallels the definition of mindfulness.

Mindfulness is attention to unfolding present moment experiences, without elaboration and judgment. Research indicates that both these aspects of mindfulness are necessary for implementing executive control (Teper et al., 2013) and that mindfulness may strengthen sensitivity to transient interoceptive indicators of distress (Farb, Segal, & Anderson, 2013). Practiced meditators are able to observe and accept emotional states, flexibly unhooking from habitual behavioral tendencies (Brown, Goodman & Inzlicht, 2013) and avoiding rumination about mood states (Creswell et al., 2007). These abilities allow for early regulation of emotional processing and behavioral responding. Thus the problem focus for clinical intervention is not the distress itself, but how an individual relates to and processes this distress. Here, mindfulness represents an antecedent focused form of regulation by improving the initial stages of executive control (Gross & Thompson, 2007).

Relation to Decision Making

Through its focus on the pivotal role of emotion as integral to the execution of behavioral control, the Affective Alarm Model (AAM) proposed by Inzlicht and colleagues (2013) has several similarities to the Somatic Marker Hypothesis (SMH) earlier put forth by Damasio (1994). Damasio argued that deficits in functional behavior and decision making are the result of an impaired ability to use emotion-based signals produced by the body (“somatic markers”) to inform response options and actions. The SMH is based on the idea that “hot” executive reasoning abilities are strongly influenced by signals generated in the neural substrates of emotion, a perspective that has been extensively studied and empirically validated by years of neuroscientific and psychological research (Dunn, Dalgleish, & Lawrence, 2006). To highlight the similarities between the SMH and the AAM, both include affect as a central feature,

appreciate the integrative nature of emotional and executive neural anatomy, and raise the importance of emotional and interoceptive awareness for enactment of adaptive behavior.

As with research of EF, the SMH has its roots in the study of neurologically impaired individuals. In his work, Damasio (1994) observed that patients with ventromedial prefrontal ablations are unable to make advantageous decisions or engage in appropriate social interaction despite intact performance on objective neuropsychological measures of attention, intelligence, memory, and executive abilities. Additionally, these patients retained a crystallized repertoire of declarative social knowledge, but were unable to execute tasks of everyday living. What was lacking was the ability to feel and express emotion in situations that normally elicit emotional reactions. Damasio, therefore, hypothesized that the dysfunction of subjective emotional experience and its corresponding neurological substrate could account for the observed pathology among these patients. Similar to the definition used in the AAM, emotion in this instance is conceptualized and defined as a holistic response involving neurochemical and physiological changes to brain-based somatosensory structures as well as to the visceral, musculoskeletal and internal milieu components of the larger physical soma (Damasio, 1994).

Neural Substrates of Emotional Control

Chief among the neuroanatomy responsible for integrating emotion, control, and behavior are the portions of the frontal lobes consisting of the ventromedial prefrontal cortex (vmPFC). Precisely, Damasio's definition of the vmPFC includes lateral portions of the orbitofrontal cortex (OFC). Whereas some controversy exists on the anatomical definition of the vmPFC (Dunn, Dalgleish, & Lawrence, 2006) and whether lateral aspects of the OFC should be included in the vmPFC (Ongür & Price, 2000), Damasio's definition will be adopted for the remainder of this review.

Neuroimaging studies have consistently linked abnormal activity in the vmPFC to personality disturbances (Barrash, Tranel, & Anderson, 2000), disorders of mood (Price, 1999; Anand et al., 2005), post-traumatic stress disorder (Milad et al., 2009), anxiety (Myers-Schulz & Koenigs, 2012), and schizophrenia (Holt et al., 2009). Although the precise role of the vmPFC in emotion regulation is not entirely understood, its activity during mood regulation and EF provides evidence for the validity of the SMH. It is currently believed that the vmPFC serves to manage emotions (Quirk, Likhtik, Pelletier, & Pare, 2003) and extinguish learned fear responses (Sotres-Bayon & Quirk, 2010) via a top-down inhibition of amygdala activity. However, a substantial literature also exists arguing that sub anatomical portions of the vmPFC (i.e. the posterior and perigenual vmPFCs) may actually underlie the experience of affect itself (Myers-Schulz & Koenig, 2012), suggesting the role of the vmPFC is complex and integrative.

Most relevant for the understanding of the vmPFC role in emotional detection and control, is the notion that structures in the vmPFC provide the material substratum for associative learning between complex external environmental situations and internal bio regulatory emotional states (Damasio, Everitt, & Bishop, 1996). The prefrontal cortex as a whole is uniquely interconnected with nearly all sensory systems as well as limbic and midbrain structures associated with memory, affect, and reward (Fuster, 2001). Although the full response of the organism involves multiple brain areas and physiological structures, the vmPFC integrates the data of the response to facilitate learning. Building on Fuster's (1984) earlier work on the prefrontal cortex as a mediator of temporal contingencies, Damasio argues the vmPFC pairs facts of the environment with the corresponding emotional reaction (somatic marker), enabling a disposition or readiness for the organism to react in a similar fashion when exposed to reminiscent stimuli. The vmPFC is neuroanatomically suited for this task given its projections

to all sensory areas (Öngür & Price, 2000) and its functional connectivity to the hippocampus during behavioral learning trials (Milad et al., 2009).

Somatic Markers and Learning

When a novel situation occurs in which some factual component has been categorized during a prior learning trial, related dispositions are activated in higher-order association cortices. The vmPFC and amygdala are activated and the somatosensory pattern, which has been paired previously with the original situation, emerges. Based on the presence of contingencies in the primary conditioning situation, the activation of these processes recapitulates an approximation of the original somatic response. People react similarly in contexts that remind them of historical events because these cybernetic neural pathways of sensory images, physiological responses, and emotional experiences have been patterned together via the integrative function of the prefrontal cortex. As proposed by Damasio, this reactivation can take place via either a bottom-up “body loop”, in which the soma actually changes in reaction to the situation conveying information to associative areas, or via a top-down “as if loop” in which somatosensory information is conveyed from the cortex, bypassing lower somatic systems. Triggering of the body loop process can explain autonomic reactions to sudden, threatening stimuli, in which fear emotions and protective behaviors commence instantly without full conscious awareness (e.g. swerving to miss an oncoming vehicle). Similarly, instigation of the top-down system can explain panic responses to cognitive rumination without the presence of a real external threat. According to Damasio’s nomenclature, the neural and physical pattern of changes evoked by this learning process is dubbed the “somatic marker.”

This learning process enables humans to respond quickly and efficiently while facilitating logical reasoning abilities. The nervous system responds to salient information in an automatic

and powerful way, prioritizing such data for further processing (Knudsen, 2007). Without this emotional, somatosensory data informing the decision making process, all potential responses are given equal value. Incorrect choices cannot be immediately dismissed because there is not corresponding “gut feeling” that rapidly communicates the need to reject it. Nor can a correct decision be quickly selected based on prior learning. This paucity of visceral information results in a slow, iterative process that may ignore previous experiences and can result in random and/or impulsive responses (Damasio, 1996). Without this neural activation pattern, among sensory and prefrontal regions, the organism either is reliant on previously overlearned behavior or is left to enact an arbitrary response (Miller & Cohen, 2001).

Although the somatic marker contains important data, the body loop and “as if” systems can activate and function within or below conscious awareness (Damasio, 1996). Most of our decisions are made without conscious attention to our somatosensory responses and feelings (Libet, 1985). If, however, awareness of bodily sensations and emotional responses included within the framework of the somatic marker can be cultivated, conscious control of behavioral responses can be enabled, resulting in greater adaptive functioning. Awareness of automatic, somatic physiological changes can instigate top-down attentional control that functions to filter out irrelevant sensory input and visceral urges to prioritize goal relevant information and actions (Knudsen, 2007).

Substance Use and Abuse

The SMH provides both a psychological and a neurological framework for understanding decision making and substance abuse. When a somatic marker (e.g. the emotional experience of anxiety and its ancillary dynamic visceral sensations) is paired with a maladaptive future outcome via prior learning, the somatic marker functions as an alarm bell. Danger is signaled.

Conversely, a positive somatic marker (e.g. the emotional experience of pleasure and reward) paired with a maladaptive behavior (e.g. substance abuse) can function to create an incentive (Verdejo-Garcia & Bechara, 2009). In both situations, the amygdala detects the environmental stimuli that are possible sources of proximal reward or punishment (Koob & le Moal, 2005). Because of its emotional function, Damasio (1994) includes the amygdala as a key component of an impulsive neural system that produces emotional responses, urges, and desires that serve to propel the organism toward an appetitive stimuli and away from aversive stimuli. When substance cues are environmentally present, such as alcohol paraphernalia, the impulsive system is activated, producing an urge to consume the substance (Verdejo-Garcia & Bechara, 2009). Without the initial elicitation of this urge, there is no need to control it.

According to the SMH, control is triggered by the impulsive system and subsequently mediated by the reflective neural system. Typically, regulation of affective responses involves increased activity of the prefrontal cortex and diminished activity of the amygdala (Harenski & Hamann, 2006), indicating that connections from the prefrontal to the amygdala impose and a top-down inhibitory regulation (Banks, Eddy, Angstadt, Nathan & Phan, 2007). This higher-order, executive, system includes the integrative function of the vmPFC, but also is dependent on two subsidiary systems responsible for EF and processing emotion. The first system includes working memory and executive processes including inhibition, planning, and cognitive flexibility abilities performed by the dorsolateral prefrontal cortex (Verdejo-Garcia & Bechara, 2009). The second subsystem involves the emotional processing function of the insular cortex and the posterior cingulate (Bechara & Van der Linden, 2005), which serve to translate raw physical changes into the subjective experience of emotion (Craig, 2003). Damage to either of these systems or structures can indirectly result in abnormal vmPFC functioning, as the vmPFC serves

to couple these systems together and initiate a control response that works to inhibit the amygdala (Verdejo-Garcia & Bechara).

There are two mechanisms by which the initial emotional response of the amygdala and the impulsive system can determine an enacted behavioral response. The first is an overactive impulsive system that exaggerates the impact of a reward. The second is an underactive reflective system that can be caused by the dysfunction of any one or all of its subcomponents. Damasio (1994) postulates substance abuse and dependence can be the result of either, or both of these dysfunctions. Mindfulness as a psychological intervention and personality trait may function neurologically to dampen the power of the impulsive system and intensify the power of the reflective system via the enactment of the executive reflective system.

Mindfulness and the Somatic Marker Hypothesis

Neuroscientific research has found increased prefrontal cortex activity and increased inhibitory control over amygdala activity is associated with mindfulness (Hölzel et al., 2011). Trait mindfulness, specifically, has been shown to increase activation in multiple prefrontal areas, including the vmPFC, and to down-regulate amygdala activity via stronger inhibitory associations (Creswell et al., 2007). Additionally, neuroimaging studies have shown changes to brain segments associated with subjective, conscious awareness of bodily sensations following mindfulness meditation training (Hölzel et al., 2011).

Given both the SMH and the ACM, provide a key role for the experience of affective and interoceptive processes for enabling executive control process and adaptive decision making, use of mindfulness training to increase bodily and emotional awareness, may improve substance abuse treatment outcomes by acting on brain centers responsible for attention and awareness. Empirical evidence is beginning to support this. For example, in a study of recovering heroin

abusers, increased scores on the observe scale of the FFMQ were associated with decreased heroin use among those at increased risk for relapse (Schuman-Olivier, Albanese, Carlini & Shaffer, 2011). Whereas trait mindfulness has been linked with a variety of substance use behaviors, specifically it has been linked to reduced use of alcohol in several investigations (Fernandez, Wood, Stein, & Rossi, 2010; Murphy & MacKillop, 2012; Garland, 2015). Importantly for clinical work, existing evidence also suggests that mindfulness-based interventions can be effective in reducing consumption of alcohol (Bowen et al., 2006; Bowen, Witkiewitz, Dillworth & Marlatt, 2007; Bowen et al., 2009; Witkiewitz & Bowen, 2010), cocaine (Avants, Beitel, & Margolin, 2005), amphetamines (Smout et al., 2010), marijuana (de Dios et al., 2011), opiates (Linehan et al., 1999; Linehan et al., 2002) and tobacco (Brewer et al., 2011; Hernandez-Lopez et al., 2009).

Summary

The AAM and the SMH provide a theoretical framework for understanding the neural and psychological processes that connect EF, mindfulness, and emotion. Whereas emotion is often ignored in studies of executive function, neuroscience research demonstrates the highly integrative nature of neural substrates believed to mediate automatic, visceral emotional processes and reflective, cortical executive responses. Through this context, awareness and acceptance of emotional experiences is essential for the enactment of executive and emotional control networks. Emotional attunement is not only adaptive, but essential for informing advantageous decision making and abstaining from self-destructive behaviors, such as substance abuse. Neuroimaging investigations indicate trait mindfulness is associated with increased activation of the responsive system responsible for managing emotional reactivity. This has

direct implications for the treatment of substance abuse disorders, as mindfulness has been associated with improved treatment outcomes.

Alcohol Abuse and College Students

Alcohol Usage and Associated Problems

According to the World Health Organization (WHO) 2014 Global Status Report, 60-80% of persons aged 15 or older living in the United States are estimated to have used alcohol, at least occasionally, within the past year. Higher rates of drinking, and a more consistent pattern of drinking, are related to the prevalence of alcohol dependence, with risk of dependence escalating linearly with increased use (Caetano, Tam, Greenfield, Cherpitel, & Midanik, 1997). In relation to problem drinking behavior, data from the 2013 National Survey on Drug Use and Health (NSDUH) show 6.6% of persons aged 12 or older (17.3 million individuals) met criteria for alcohol dependence or abuse (SAMHSA, 2013). Of those, young adults aged 18-25, represented the highest percentage of dependence and abuse (13%), with only 5.3% receiving treatment (SAMHSA, 2013). Of all users surveyed by the NSDUH, 90.6% perceived no need for treatment and young adults aged 18-25 were the least likely to have received treatment for alcohol abuse within the past year (SAMHSA, 2013). Whereas dependence and abuse are discreet clinical concepts, general alcohol use follows a continuum, with current evidence indicating subthreshold, yet problematic, levels of drinking occurring broadly among the young-adult population (Babor, 2010).

Young adults enrolled full-time in college report higher levels of alcohol consumption compared to their non-college peers, with 63% of college students and 56% of non-college students reporting use of alcohol in the past 30 days (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2015). This difference holds when examining type and frequency of

alcohol use behavior. There is a higher prevalence of heavy drinking (five or more consecutive drinks) among college students (35%) than among non-college respondents (29%; Johnston et al., 2015). Additionally, 43% of college students report drinking to intoxication compared to 34% of non-college peers (Johnston et al., 2015). This trend in differences between college students and non-attending peers has held for decades, with college students demonstrating the highest levels and greatest consistency of alcohol use since 1980 (Johnston et al., 2015). Overall, nearly 20 percent of college students meet DSM-IV criteria for alcohol abuse or dependence (Hingson, 2010), contrasting with findings that college-bound students are far less likely to drink in high school than non-college bound students (Johnston et al., 2015). Such antithetical outcomes in college, given prior behaviors in high school, highlight the college population and environment as areas of interest for studying alcohol use.

Common use of alcohol both worldwide and domestically presents a major risk to physical and mental health. Globally, 5.9% of all deaths in 2012 (3.3 million individuals) were attributable to alcohol abuse (WHO, 2014) and there are an average of 2,221 alcohol poisoning deaths in the United States every year (Kanny et al., 2015). The most notable diseases caused by prolonged alcohol abuse include cirrhosis (Lieber, 1988), fatty liver (Sherman & Williams, 1994), digestive problems (Kelly et al., 1995). Other pervasive morbidities includes damage to the cardiovascular system with alcohol abuse linked to acute cardiac arrhythmias, damage to heart tissue, and hypertension with subsequent increased risk of stroke (Friedman, 1998). In the United States, an estimated 18,200 to 21,300 (3.2-3.7%) of all cancer deaths were ascribed to excessive alcohol consumption (Nelson et al., 2013). Neuropsychologically, alcohol abuse is associated with brain damage, peripheral neuritis, and dementia (Harper, 2007), as well as mental health connections with depression (Grant & Hartford, 1995), and anxiety (Conway,

Compton, Stinson, & Grant, 2006). It is clear that alcohol consumption is a major contributor to morbidity and mortality, with risk of diseases, impairments, and disorders increasing with the amount of alcohol consumed.

Although long-term health consequences of alcohol abuse pose a grave public health concern, immediate problems due to ethanol intoxication present yet another serious challenge. Intoxication is defined as an acute functional impairment in physical and psychological performance brought on by the pharmacodynamic action of alcohol (Babor, 2010). The state of intoxication is complex, determined by dose and rate of consumption, and involving multiple neurological and physiological systems, as well as several personal (e.g. sex, genetics, body size) and environmental (e.g. situation, culture, place) variables (Babor, 2010). Research has determined that intoxication is a key risk factor for adverse consequences of alcohol use, especially among college populations. Approximately 25 percent of college students report adverse academic consequences of alcohol use, including missing class, falling behind on course work, poor exam performance, and lower grades (Wechsler & Nelson, 2008). A 2001 national survey indicated that 690,000 college students were physically assaulted and 97,000 college students were sexually assaulted by an intoxicated student peer (Hingson, Heeren, Winter, & Wechsler, 2005). Among all college students, 29.2 percent have driven under the influence (Hingson, 2010), and 19 percent of all unintentional alcohol related injuries and motor vehicle accidents resulted in death (Hingson, Zha & Weitzman, 2009). The occurrence of alcohol-related fatalities due to injury has increased by three percent during the last decade (Hingson, 2010). From a public health perspective, this also impacts the larger community beyond college campuses, as 46 percent of all people killed 2005 crashes involving drunk drivers were individuals other than the impaired driver (Hingson, 2010).

Alcohol and Executive Function

A long literature exists documenting EF impairments among substance abusers. However, the study of the specific relationship between alcohol abuse and diminished executive abilities has been challenging due to confounds created by high rates of polysubstance use within this population (Fernandez-Serrano, Perez-Garcia, Schmidt Rio-Valle & Verdejo-Garcia, 2010). Decrements in the EFs of planning and cognitive flexibility have been documented among polysubstance users who also abuse alcohol (Bolla, Funderburk, & Cadet, 2000, Fishbein et al., 2007; Goldstein, & Volkow, 2011) and hierarchical regression models, used to statistically address the polysubstance abuse confound, indicate robust associations between the amount of alcohol use and detriments to verbal fluency and decision making, as measured by the Iowa Gambling Task (IGT; Fernandez-Serran et al.). Poor IGT performance among abusers of alcohol has been demonstrated repeatedly, indicating connections among EF, decision making associated emotional processes (Verdejo-García, Pérez-García, Bechara, 2006). Studies that have probed the independent effects of alcohol use on EF, have typically focused on the college students, given the high availability increased rates of drinking within this population. College students who engage in binge drinking behavior show poorer performance on tasks of planning and attention (Hartley, Elsabagh & File, 2004), visuospatial working memory (Weissenborn & Duka, 2003), working memory (Giancola, Zeichner, Yarnel & Dickson, 1996) inhibitory control, and cognitive flexibility (Townshend & Duka, 2005).

In addition to neuropsychological data, brain imaging studies have demonstrated neuroanatomical abnormalities across regions of the frontal lobes among abusers of alcohol (Goldstein & Volkow, 2011). For example, attenuated cerebral blood flow to the prefrontal cortex is associated with diminished EF task performance and poor treatment prognosis (Norman

et al., 2002). Alcoholics also demonstrate up to a 20% reduction in grey matter density in the dorsolateral prefrontal cortex, with impairments in EF increasing as a function of lifetime alcohol abuse (Chanraud et al., 2007). This reduction persists following abstinence from use, suggesting stable, trait-based factors may predispose such individual to develop substance abuse (Chanraud et al., 2007). These abnormalities are associated with maladaptive decision making and diminished performance on EF tasks, thereby prolonging disadvantageous behavior and presenting serious implications for treatment effectiveness (Goldstein & Volkow, 2011). Despite these neuroanatomical and neuropsychological outcomes in advanced alcoholics, less is known about the etiology of alcohol related neuropathology, prompting a need to study younger subjects at earlier stages of this developmental trajectory.

College students constitute a population of considerable interest when examining the relationship between EF and alcohol abuse. This is primarily due to the unique developmental status of these young adults, which includes increased accessibility of alcohol at a time when the frontal lobes have not matured completely. The frontal lobes and their connective pathways are among the last of the brain areas to fully develop (St. James-Roberts, 1979). Although the morphological architecture of the frontal lobes is complete at puberty, myelination of connective pathways and concurrent changes in neuronal density and synaptogenesis continue through early adulthood (Romine & Reynolds, 2005). Consistent with these physical findings, the continued development of EFs have been documented into early adulthood with efficiency of working memory, planning, and problem-solving abilities undergoing further change through age 29 (DeLuca et al., 2003). Neurophysiological maturation of the frontal lobes co-varies with cognitive functioning (Grattan & Eslinger, 1991) and may therefore be at least partially responsible for differences in EF that lead to differences in alcohol use. Given documented

association between EF and mindfulness, levels of trait mindfulness among the developing college population may also contribute to alcohol use.

Alcohol and Mindfulness

Many mindfulness interventions designed to address problematic behavior in adolescents have been implemented with varying success. It has been argued that variability in successful outcomes may be attributable to the developmental appropriateness of various interventions (Sanger & Dorjee, 2015). Mindfulness training in adolescents has targeted attention monitoring and control systems of the PFC, which thought facilitate development of the PFC and reduce risky behavior (Spear, 2013). However, to date, this hypothesis has yet to be confirmed and little is known about the relationship between the developmental trajectories of mindfulness and EF processes during adolescence (Sanger & Dorjee, 2015). College students also present a population of interest for investigation of mindfulness abilities, given their developmentally unique transitional placement between adolescence and adulthood. Because Mindfulness is theorized to interfere with the automatic enactment of impulsive and destructive behaviors, it has been proposed as a potentially useful aid for addressing abusive alcohol consumption. Mindfulness is believed to decrease multiple forms of substance abuse by increasing awareness of cue triggers and functioning as a cognitive tool for observing and accepting urges without acting upon them (Marlatt et al., 2004). Although research in mindfulness has increased exponentially during the past decade, there remains a paucity of high quality studies investigating the relationship between mindfulness and alcohol use.

Existing evidence suggests increased levels of trait mindfulness are predictive of decreased alcohol use. Negative relationships have been found between the “Nonjudging” facet and overall alcohol consumption, and between the facets “Acting with Awareness”,

“Nonjudging”, “Nonreactivity”, and adverse alcohol-related consequences (Murphy & MacKillop, 2011). However, the role of trait mindfulness in predicting alcohol use appears to vary depending upon which aspect of mindfulness is examined and what measures are used. For example, work by Leigh and Neighbors (2009), using the Freiburg Mindfulness Scale to study mindfulness and alcohol use in college students, indicated that students reporting higher levels of mind/body awareness also reported higher rates of alcohol use. Conversely, men in the same study reporting less attachment to their thoughts and emotions reported less alcohol consumption. Fernandez, Wood, Stein, and Rossi (2010) investigated relationships among all factors of the Five Facet Mindfulness Questionnaire (FFMQ; Baer, 2006) and found significant negative associations between alcohol use and Acting with Awareness, Describe, and Nonjudging facets. Inconsistent with results of the Leigh Neighbors study, Fernandez and colleagues found no significant relationship between their “Observe” factors measuring mind/body awareness. A subsequent study by Eisenlohr-Moul, Walsh, Charnigo, Lynam and Baer (2012) partially clarified this discrepancy in that the “Observe” facet of the FFMQ was associated with more periods of alcohol use, but only when participants also reported lower levels of “Nonreactivity”. This suggests impulsivity or dysfunctional forms of awareness (e.g. rumination) may mediate the relationship between the “Observe” factor and alcohol consumption. Given these inconsistencies and the presence of potentially confounding variables, full understanding of the relationships among mindfulness factors and alcohol use remains elusive.

A large body of literature has explored the relationship between impulsivity and alcohol abuse, with numerous investigations consistently supporting a bidirectional predictive relationship between impulsivity and alcohol abuse (Dick et al., 2010). Consequently, the

impact of impulsivity should be considered when studying factors that influence alcohol consumptions. Given that impulsivity reflects a commanding present-moment orientation, it would appear to overlap with the present-centered aspect of the mindfulness construct; however they operate in a reciprocal manner (Murphy & MacKillop, 2012). Whereas impulsivity involves a powerful urge to act without consideration of future consequences, mindfulness functions to curtail reactivity. Granting this relationship the role of both impulsivity and mindfulness in predicting alcohol use has been investigated. Murphy and MacKillop (2012) found that, although mindfulness predicted alcohol use, this relationship was completely mediated by impulsivity. In their analysis, the predictive nature of mindfulness was found to be a function of impulsivity despite highly variable associations between the two constructs, suggesting the two traits were similar in some respects and distinct in others. The urgency factor of impulsivity— or a propensity to act rashly in response to a strong affective state – was most predictive of alcohol use, and is one area in which impulsivity and mindfulness overlap reciprocally. What remains unclear is how these two personality traits are related – independently, redundantly, reciprocally, or otherwise – to neuropsychological executive abilities.

Summary

Alcohol abuse is a pervasive phenomenon across the globe that disproportionately impacts young adults and college students in particular. Despite clear adverse risks and consequences associated with both acute and chronic alcohol abuse, drinking has remained pervasive on college campuses. This reality has held in the face of expanding alcohol control and prevention policies that seek to decrease the availability of alcohol, while bolstering enforcement and treatment interventions. Given the intransigence and prevalence of this

problem, years of research have investigated factors that influence and diminish alcohol consumptions and related difficulties among young-adults. Alcohol abuse is associated with multiple EF abilities, including attention, inhibitory control, cognitive flexibility, and decision making, and attenuated grey matter density in areas of the prefrontal cortex. Evidence indicates trait mindfulness is a predictor of reduced alcohol consumption; however additional research is needed given variability in research methodologies and inconsistent findings.

Rationale for the Current Study

In the context of the existing literature, an examination of the facets of mindfulness and their connection to EF and prefrontal cortex functioning can better inform the use of clinical methods in neuropsychology and behavioral medicine. Clear associations exist among EF, mindfulness, and alcohol use; however, the precise nature of these relationships and the firm conclusions regarding the predictive utility of existing measures of the EF and mindfulness for treatment remains elusive. It is known that both EF and mindfulness are predictive of alcohol use (Bowen et al., 2006), psychopathology (Tang et al., 2012; Murphy & MacKillop, 2011) and health behaviors (Hall, Fong, Epp, & Elias, 2008; Mars & Abbey, 2010). However, the potential discriminative and additive predictive values of these constructs for clinical treatment when taken together is unknown.

A common problem with objective measures of EF is their poor predictive utility for behavior in the wider ecological sphere (Manchester, Priestly, & Jackson, 2004), requiring the supplemental use of self-report measures for more accurate interpretive findings (Suchy, 2009). As such there is no current “gold standard” EF test or assessment battery (Royall et al., 2002). Similarly, much has been made of mindfulness in recent years, yet the theoretical underpinnings of the construct remain unclear (Sedlmeier et al., 2012). Mindfulness measures may be one self-

report strategy that can better round out neuropsychological assessment of executive capacities and prefrontal functioning, thereby improving assessment practices and treatment planning. An empirical demonstration of a significant relationship between a popular measure of mindfulness and classic EF tests can support claims of mindfulness' importance in evaluation and intervention. To date, no study has compared the multifaceted structure of EF supported by Miyake, Friedman, Emerson, Witzkie and Howerter (2000) and the multifaceted structure of mindfulness purported by Baer, Smith, Hopkins, Krietemeyer, and Toney (2006). Additionally, little mention of emotion is ever included in models of executive function (such as the one proposed by Miyake and colleagues), nor is it included in popular measures of EF (such as the D-KEFS). The study of these multifaceted models of EF and mindfulness remain ongoing, therefore an empirical investigation of commonalities between that includes emotional measures them may be highly informative. An analysis of complex constructs such as EF and mindfulness that includes measurement of multiple component facets given documented variability in functioning and measurement among indices of EF (Jurado & Rosselli, 2007) and mindfulness (Baer et al., 2006).

The use and abuse of alcohol is an important area of study relating to wellness and provides a practical topic for investigation relating to the explanatory power of EF and mindfulness. Mindfulness is thought to attenuate alcohol abuse by facilitating awareness of cue triggers and functioning as strategy for observing and accepting urges while refraining from action (Marlatt, 2004). Present findings of the predictive utility of mindfulness vary depending on which facets are explored and which measures are used, leaving a comprehensive understanding of the construct's relationship to alcohol use unknown. Similarly, executive dysfunction is a significant contributor to difficulties engaging in healthy behaviors (Hall, Fong,

Epp, & Elias, 2008; Tarter, Kirisci, Habeych, Reynolds, and Vanyukov, 2003), yet existing tests of EF often fail to capture impairments that are predictive of actual behavior (Manchester, Priestly, and Jackson, 2004). A better understanding of the relationship among EF objective tests and self-report measures of similar psychological constructs such as mindfulness and impulsivity may increase the precision and validity of assessment conclusions within the EF domain. These improved evaluation practices can result in better tailored treatment plans and interventions for treatment of disorders associated in executive dysfunction.

The current investigation adds to research on EF, mindfulness and alcohol use while addressing the limitations of existing literature research through three primary goals. First, this study will examine the relationships among the facets of mindfulness and three purported EFs identified by the current literature. Investigating similarities among these facets may further illuminate the underlying quality of these complex entities and add to the utility of components of EF and mindfulness when taken together to predict alcohol use. Second, this study seeks to further explicate the relationship among mindfulness, emotional control, impulsivity and decision making for predicting alcohol use in a population at risk for abuse. Although lines of research exist in each of these areas, no study has sought to examine them concurrently, using a statistical analysis capable of revealing complex relationships among these variables. Third, the results of this study may add further support to the SMH and the AAM as models for understanding decision making and substance use by supporting emotional control and frontal executive processes as predictive correlates of alcohol use. Using these models, mindfulness as an intervention may also offer a useful strategy for impacting this connection in a clinical setting. If, as proffered by Teper and colleagues (2013), mindfulness results in improved emotional control and behavioral health outcomes via improvement of EF, elucidating the relationship

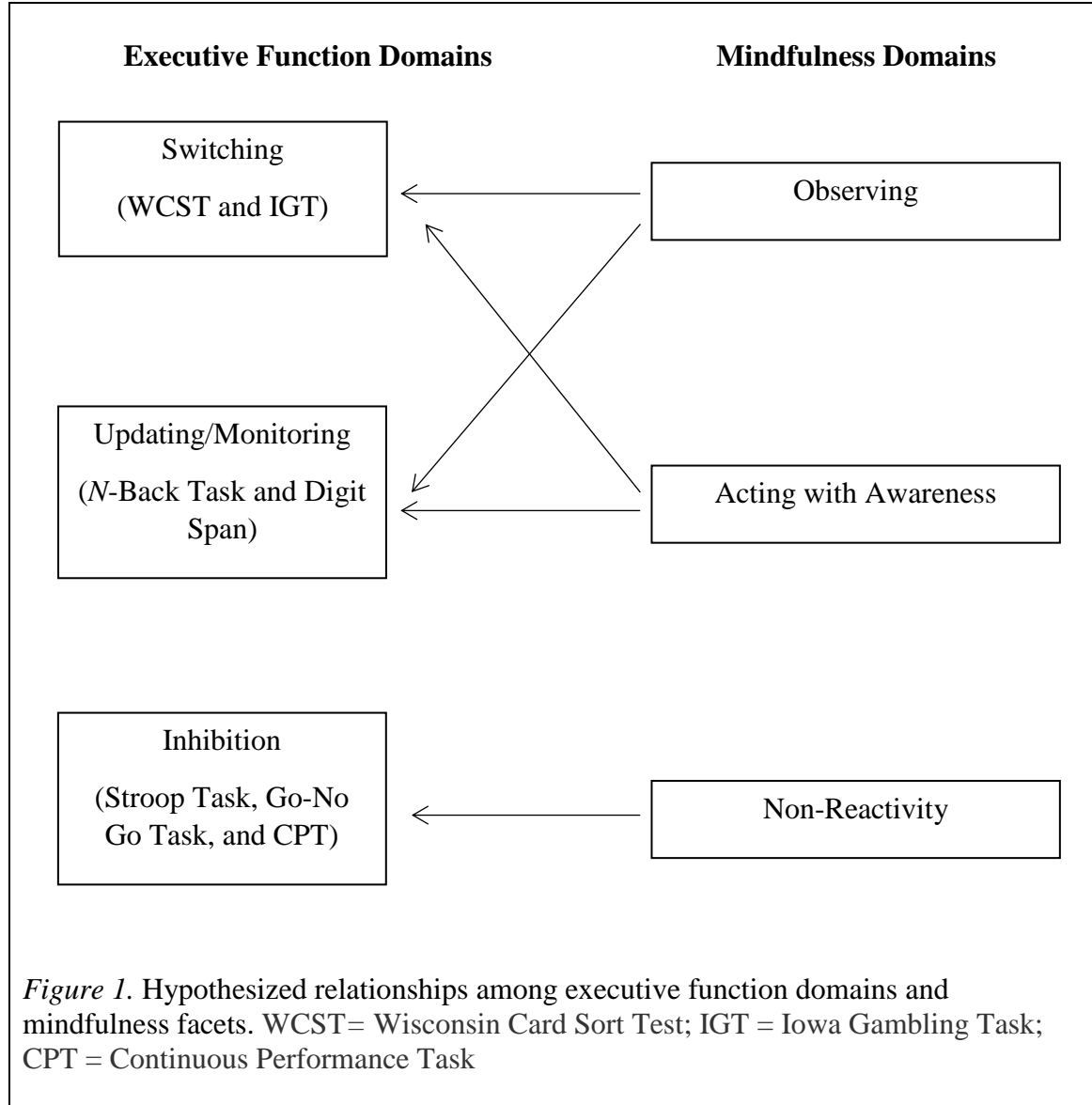
between impulsivity and mindfulness may lend further support for using mindfulness as a technique to address impulsive behavioral problems. Taken together, these may help propel further research on the vital role of emotion in the executive processes of the prefrontal cortex.

Hypotheses

Given the state of the current literature several hypothesis have been made for the current investigation:

- 1) It was predicted that the three basic executive abilities derived by Miyake and colleagues (2000) are necessary for the three facets of mindfulness that are conceptually related to EF to be performed successfully. Specifically, *Nonreactivity* on the FFMQ will vary with inhibition (Stroop Color-Word Test, Go/No-Go Task, and Continuous Performance Task), whereas *Observing and Awareness* will vary with monitoring (*N*-Back and Digit Span Tasks) and set shifting capabilities (WCST and IGT). A schematic of the proposed relationships among EFs and mindfulness facets is provided in Figure 1.
- 2) It was predicted that better EF performance on the WCST, Stroop Color-Word Test, and *N*-Back will correspond with higher levels of adaptive emotional responding on the ERQ and emotion-based decision making on the IGT.
- 3) It was predicted that higher levels of trait mindfulness on the subscales of the FFMQ will correspond with higher levels of adaptive emotional responding on the ERQ and emotion-based decision making on the IGT. In accordance with the affective alarm model, *Observing* and *Nonjudgment* facets of mindfulness will be the greatest mindfulness predictors of emotion based decision making on the IGT. It was predicted that individuals scoring higher in emotional reappraisal strategies on the ERQ would also report higher levels of mindfulness.

- 4) It was predicted that lower levels of impulsivity on the UPPS-P would be associated with higher levels of mindfulness on the FFMQ. Although mindfulness predicts alcohol use, this has been shown by some studies to be a function of impulsivity (Murphy and MacKillop, 2012). What remains unclear is how these two personality traits differentially or similarly relate to neuropsychological executive abilities and alcohol use when taken together.
- 5) It was predicted that better EF performance (as measured by the WCST, Stroop Color-Word Test and *N*-Back task) and higher levels of trait mindfulness (as measured by the subscales of the FFMQ) would correspond with lower levels of alcohol consumption on the DDQ-R and lower levels of alcohol related problems reported on the RAPI.



CHAPTER II

METHOD

Measures

Executive Function

Wisconsin Card Sort Test. The Wisconsin Card Sort Test (WCST) is a well-known tool within the existing canon of executive function measures of abstract problem solving abilities. Because the test requires the capacity to alternate strategies and flexibly respond to changing task demands, it has been selected as a representative measure of the switching executive function presented by Miyake and colleagues (2000). In the WCST a target card is presented on the screen and the participant is tasked with matching this card to any of four reference cards. It is possible to match the cards according to three categories: color, number, shape. Only one category is correct at a time. The participant is not told how to match the cards, but is given feedback for each sort indicating if the sort was correct or incorrect, depending on the preset correct category. After the participant correctly sorts the cards over 10 consecutive trials, the category is abruptly changed by the administrator without warning to the participant, leaving the participant to flexibly adapt and discover the new sorting rule. The test continues until the participant achieves six correct categories of sort, or all 128 cards are presented. A number of scores are provided by the test; however the primary dependent measure utilized for the present investigation will be the number of perseverative errors, given this is thought to be an index of the executive function of switching between mental sets (Miyake et al., 2000).

Reliability and validity data for the task vary by age and clinical status (Nyhus & Barceló, 2009); however the most recent norms derived from normal subjects by Heaton and colleagues (1993) show adequate reliability with generalizability coefficients ranging from .37 to

.72 for the various score indices provided by the test. The mean coefficient for the Heaton sample was .57. Multiple factor analytic studies have also been performed to examine validity across populations, and have revealed three factors of set shifting, problem solving, and response maintenance (Greve, Stickler, Love, Bianchini, & Stanford, 2005). When examined against other measures of EF, the WCST tends to load on a separate factor, implying that it measures a type of conceptual processing not captured by other tests (Stuss, 2006). Structural equation modeling of the WCST showed it to be a significant predictor of the “shifting” ability of EF both among healthy young adults and a broad age spectrum (Miyake et al., 2000; Fisk & Sharp, 2004).

Stroop Color and Word Test. The Stroop task (Stroop, 1935) is a popular task with an established tradition of utilization among researchers and clinicians (Strauss, Sherman & Spreen, 2006). It has been selected to represent the inhibition function described by Miyake and colleagues (2000). Errors on the Stroop task have been shown to predict mindful acceptance (Teper & Inzlicht, 2013) and impulsivity (Lansbergen, Van Hell, & Kenemans, 2007). The Stroop task requires the examinee to inhibit an automatic, dominant response in favor of a novel response. In the color-word variant, participants must inhibit over-learned tendencies to read printed words, while instead naming the color of ink used to print the words. This inhibition task is difficult, given that participants are under time constraints and ink colors differ from the printed words. For example the word “BLUE” may be printed in red ink, requiring the participant to refrain from saying “blue” and respond correctly by saying “red”. The performance score for this study is defined as the proportions of correct colors identified correctly during a 45 second trial in which printed words and colors are incongruent.

Reliability coefficients for the Color-Word trial of the Stroop task used in the present study range from .67 (Franzen, Tishelman, Sharp & Friedman, 1987) to .73 (Golden, 1975).

Functional imaging studies of young adults have also linked Stroop task performance to activation of frontal brain areas (Peterson et al., 2002) and performance on the Color-Word inhibition trial for the Stroop task has been shown to be predictive of damage to dorsolateral prefrontal cortical regions (Gläscher et al., 2012). Scores on the inhibition trial have also been found to correlate moderately well with other tests of attention and prepotent response inhibition (Strauss, 2006).

Go-No Go Task. The computerized Go-No Go (Firmore, 2003) task was selected as a behavioral, objective EF measure of response inhibition. In this task, the participant is presented with an outline of a rectangle and instructed to press a key if the rectangle is filled with one color (the target) and instructed to refrain from pressing the key if the rectangle is filled with an alternative color (the false alarm), thus requiring vigilance and the participant to alternate his or her response according to unanticipated stimulus changes. The task has been used previously as a measure of impulse control in studies of children with Attention Hyperactivity Disorder (Derefinko et al. 2008) and adults with history of substance abuse (Firmore & Rush 2006). The score used for analysis was the error rate calculated by the number of correct responses divided by total number of stimuli presented.

N-Back Task. The *N*-back task was selected to represent the updating executive function yielded by Miyake, Friedman, Emerson, Witzkie and Howerter (2000) in their study of the unity and diversity of EF, given the task requires active monitoring and manipulation of memory representations. In the Single *N*-back task, participants are shown a sequence of visual stimuli and ask to determine whether the current stimulus matches the stimulus displayed *N* trials previously. In their computer version of the *N*-back task originally developed by Kirchner (1958), Jaeggi and colleagues (2010) present visual stimuli consisting of eight random shapes

shown in yellow against a black screen. Each stimulus is presented for 500 ms, with a 2500 ms interval between each stimulus. Participants are instructed to respond positively to target symbols by pressing a key, whereas no response is required for non-target stimuli. The length of time permitted for target symbol and participant response is 3000 ms. Participants are given increasingly difficult ordered trials of 2-, 3-, and 4-back levels. Each level is comprised of three consecutive blocks, producing nine total blocks for the task. In each block, 20+n stimuli containing six target stimuli are presented along with 14+n non-target stimuli. The dependent measure is a composite score of the proportion of hits minus false alarms averaged across all *N*-back levels.

Several studies have explored the reliability of the *N*-Back task, yielding coefficient ranging from .02 to .91 (Jaeggi et al., 2010). Reliability is strongest on higher task levels requiring memory of at least two and three steps back, which is likely due to ceiling effects on easier trials (Jaeggi). Coefficient at the higher levels when using composite scores exceed .80 (Jaeggi). Studies of construct validity of the *N*-back task as a measure of executive working memory yield coefficients of .12 to .55 when compared against simple span measures of working memory (Jaeggi). The *N*-back also has strong correlations with measures of EF, including the Stroop ($r=.55$) the WCST ($r=-.56$) and verbal fluency ($r=-.59$), supporting its use as an index of an EF factor (Ciesielski, Lesnik, Savoy, Grant, & Ahlfors, 2006). Additionally, functional neuroimaging studies have found robust activation of the dorsolateral and ventrolateral prefrontal cortex for subjects performing the *N*-back task, lending further endorsement for its use in measuring frontal executive abilities (Owen, McMillan, Laird, & Bullmore, 2005).

Digit Span. Monitoring capability was assessed using the forward and backward computer versions of the Auditory Digit Span Task. In this task participants are cued to begin

the task and subsequently hear digits ranging from one through nine spoken at the rate of one digit per second. In the forward version, participants next typed digits in the same order presented, whereas the backward version requires participants to type presented digits in the reverse order. Scores on both versions are calculated by finding the highest number correctly recalled digits before making two consecutive errors. The score used for this study was the total of correctly recalled digits forward and correctly recalled digits backward. Auditory digit span tasks have a long history of use in both clinical and research assessments and have been shown to be reliable and valid measures of working memory and attention (Conway et. al, 2005).

Impulsivity

UPPS-P Impulsive Behavior Scale. The UPPS-P Impulsive Behavior Scale is a revised 59 item self-report measure that assesses five domains of impulsivity. It includes the original 45 items constructed by Whiteside and Lynam (2001) to assess four personality facets of impulsive behavior, including Urgency, (lack of) Premeditation, (lack of) Perseverance and Sensations Seeking. An additional 14 items are also included to provide a Positive Urgency subscale, given the propensity to act rashly to positive affective states has been shown to explain additional variance for predicting risky behaviors beyond the original four facets (Cyders et al., 2007). Longitudinal and cross-sectional studies support the power of impulsivity to predict drug use of many kinds (De Wit, 2008) and Sensation Seeking, Urgency, and lack of premeditation, facets of impulsivity have documented utility among college students for predicting alcohol consumption and tendencies to engage in risky behaviors (Jones, Chryssanthakis & Groom, 2014). The UPPS-P utilizes a Likert scale response format for each item ranging from one (agree strongly) to four (disagree strongly), as well as reverse scoring for some items. Subscale scores are determined by calculating the mean for each subscale, with higher scores indicating

higher levels of impulsivity. Internal reliability coefficients for each subscale of the UPPS-P is greater than 0.80 (Cyders et al., 2007). Factor analytic study has shown the five subscales also have good validity as measures of distinct contributory factors of the overall impulsivity construct. The subscales have also shown predictive validity for different aspects of risky behavior, with Sensation Seeking associated with the frequency of engaging in risky behaviors, and Urgency associated with problem levels of involvement in risky behavior (Smith et al., 2007).

Continuous Performance Task. The Continuous Performance Task (CPT; Rosvold et al., 1956) was selected to provide an objective, behavioral measure of vigilance. In this task, participants are presented with a series of letters and instructed to press a key only when presented with the letter “X”, while inhibiting responding to all other stimuli. Stimuli are presented at a fixed rate of 920 ms between presentations, and target stimuli are relatively infrequent, thus requiring participants to sustain attention over time while continually inhibiting the impulse to press a key following stimulus changes. The CPT, and multiple variations of the task have been used for decades as a reliable and valid measure of sustained attention and response inhibition across many clinical populations (Riccio, Reynolds, & Lowe, 2001).

Mindfulness

Five Facet Mindfulness Questionnaire. The Five Facet Mindfulness Questionnaire (FFMQ) is a comprehensive 39 item self-report measure that includes five aspects of mindfulness derived from empirical factor analyses of previously validated mindfulness measures (Baer et al., 2006). Subscales comprising the five facets of mindfulness include 1) *Nonreactivity* 2) *Observing* 3) *Acting with Awareness* 4) *Describing* and 5) *Nonjudging of Experience*. Individual items on the FFMQ are rated on a Likert scale ranging from one (never

or very rarely true) to five (very often or always true). In prior research, the higher scores on the FFMQ have been predictive of improved executive control and less preoccupation with alcohol (Ostafin, Kassman, & Wessel, 2013). Internal consistency coefficients for the FFMQ are good to excellent ranging from 0.84 to 0.92 (Siegling & Petrides, 2014). The FFMQ has also been validated against other existing measures of the mindfulness construct, including the Kentucky Inventory of Mindfulness Skills ($r = 0.90 - 0.92$), the Cognitive and Affective Mindfulness Scale – Revised ($r = 0.67 - 0.77$), the Southampton Mindfulness Questionnaire ($r = 0.50 - 0.72$), the Mindful Attention Awareness Scale ($r = 0.52 - 0.60$), and the Freiburg Mindfulness Inventory ($r = 0.59 - 0.70$; Siegling & Petrides, 2014).

Emotion and Decision Making

Iowa Gambling Task. The Iowa Gambling Task (IGT) was selected as a measure of emotion guided decision making. Previous studies have shown decreased performance on the task among abusers of alcohol (Bechara, Dolan, Denburg, Hindes, Anderson, & Nathan, 2001) and several other substances (Verdejo-Garcia & Bechara, 2009) suggesting decision making impairments and maladaptive behaviors are partly the result of an underlying dysfunction in processing psychophysiological emotional data (Crone et al., 2004). The IGT is a computer based test in which participants must choose among four decks of cards. Each time examinees select a card they are given visual and auditory feedback in the form of simulated financial gain. If they have won money, the computer tells them how much they have won, produces a distinctive sound, and provides visual feedback that money has been gained. If they have lost money, the computer tells them how much they have lost, produces a different sound, and displays visual feedback that money has been lost. This feedback is thought to elicit a visceral emotional response, which is postulated to inform future card selection (Bechara et al., 1994).

Two disadvantageous decks provide immediate reward by simulating high financial gain, yet yield distal punishments by producing future losses over the long-term (Bechara et al., 2000). The remaining two advantageous decks provide smaller rewards and simulated financial gain, but mitigate future losses (Bechara et al., 2000). The IGT yields multiple scores, including a total score of net money won during the task. Positive scores indicate adaptive decision making, whereas negative scores indicate impaired decision making (Bechara, 2007). Abusers of alcohol have consistently demonstrated impaired performance on the IGT, suggesting associations among executive function, decision making, and related emotional processes (Verdejo-García, Pérez-García, Bechara, 2006).

Emotion Regulation Questionnaire. The Emotion Regulation Questionnaire (ERQ) is a rationally derived 10 item self-report measure designed to assess emotion regulation strategies utilized by participants. Theorists have articulated two primary types of emotion regulation strategies: types that occur early in the development of an emotional experience and types that occur after an emotional response is elicited (Gross & Thompson, 2007). The ERQ divides emotional regulation attempts into two categories. The first, Reappraisal, represents an early, adaptive strategy. The second, Suppression, represents a later, maladaptive strategy. Individual items on the ERQ are rated on a Likert Scale ranging from one (Strongly Agree) to seven (Strongly Disagree). Items load differentially onto the Reappraisal and Suppression subscales, which have been empirically distinguished via factor analysis (Gross & John, 2003). Alpha reliabilities averaged .79 for the Reappraisal subscale and .73 for the Suppression subscale and test-retest reliability across three months was .69 for both subscales (Gross & John, 2003).

Alcohol

Daily Drinking Questionnaire-Revised. The Daily Drinking Questionnaire-Revised (DDQ-R; Kruse, Fromme, & Corbin, 2005), is based on the original DDQ used by Collins, Parks & Marlatt (1985) in their study of alcohol use among college students. The DDQ-R is a self-report measure of frequency, amounts, and patterns of alcohol consumption for the previous 30 days. Participants are provided with the definition of standard drink measures for beer, wine, and malt liquor and varying concentrations of alcohol content. They are asked to report number of drinks and number of hours drinking for a typical week and their heaviest drinking week within the last 30 days by writing on a calendar. This strategy disaggregates quantity and frequency of alcohol consumption, yielding more accurate estimates of drinking intensity and regularity (Hunsley & Mash, 2008). The dependent variable calculated from the DDQ-R will include total beverages consumed during a typical week. The DDQ-R is a continuous measure, allowing for the capture of alcohol use that may not meet clinical criteria for abuse and dependence. Self-report quantity and frequency indices of alcohol consumption, such as the DDQ-R, have adequate to excellent reliability and validity and resemble well-validated interview measures of alcohol consumption, such as the Alcohol Timeline Followback TLFB (Hunsley & Mash, 2008). Prior research has also shown self-reports to be consistent with other assessment strategies that estimate actual alcohol use, including biological markers of liver function and reports from collateral informants (Babor, Steinberg, Anton, & Del Boca, 2000). Self-reports have been found particularly accurate when participants are ensured responses will be anonymous (Del Boca & Darks, 2003), as will be the case in the current study. Because a large body of literature has supported accuracy of self-reports, they have become an accepted practice among alcohol researchers (Del Boca & Darks, 2003).

Rutgers Alcohol Problem Index. The Rutgers Alcohol Problem Index (RAPI) is 23 item self-report measure used to assess alcohol related problems (White & Labouvie, 1989) that has been used extensively to study alcohol abuse among college students (Neal, Corbin & Fromme, 2006). The RAPI uses a Likert scale ranging from one (never) to five (more than 10 times) to assesses the frequency of 23 adverse consequences of alcohol use experienced over the past three months. Previous research using the RAPI has shown good internal reliability and validity (Vaughn, Corbin, & Fromme, 2009; Neal et al, 2006) with results for a reliability study among college yielding test-retest correlations ranging from .89 to .92.

Demographics

Demographic Questionnaire. For descriptive purposes, participants will be administered questions regarding age, biological sex, race, and academic status (e.g. freshman, sophomore, etc.). There are known differences concerning the use of alcohol between women and men. Although lifetime prevalence of alcohol use between college men and college women is nearly exact (79.1% for men and 79.7% for women), patterns of drinking differ by gender with men reporting a higher frequency of intoxication, binge drinking, and extreme binge drinking (Johnston et al., 2015). Given this documented divergence of alcohol consumption between men and women, the gender identification will be collected and examined in statistical analyses. Variables of age, race, and academic status will be compared against dependent variables of EF, mindfulness, emotion, and impulsivity to investigate their relative value in predicting variance of alcohol use.

Procedures

Study participation occurred during the spring 2016 academic semester in Uhler Hall on the main campus of Indiana University of Pennsylvania (IUP). Participants were college

students recruited through the SONA system of the General Psychology Subject Pool. Because this investigation was primarily interested in exploring the general relationships between the constructs of EF and mindfulness in predicating alcohol use among young adults, recruitment restrictions were opened to all students enrolled in General Psychology courses. After electing to join the study, participants chose from a selection of available appointments for a session time. Testing took place in a quiet exam room in Uhler hall that included four computer stations. Once seated in the study room, participants were provided with an informed consent document by the author. Participants were given the opportunity to review the form and to ask questions of the examiner prior to signing. Following consent, each participant underwent administration of demographic, self-report, and objective test measures. The sequence of administration of these measures varied by participant to guard against order effects. Self-report measures, including the demographic questionnaire, FFMQ, UPPS-P, ERQ, DDQ-R, and RAPI were administered via the “Qualtrics” secure internet-based survey program. Objective performance measures, including the WCST, Stroop Color-Word Test, *N*-Back, Digit Span, CPT, and IGT were administered according to standardized procedures via the “millisecond” software. Each participant was given a unique identification number to aid in organization of data; however, the identification numbers were not linked to the participant’s name, rendering anonymous all responses and performances. Data were stored in the Qualtrics and millisecond programs, to which only the primary investigator had access. Signed informed consent documents were stored separately in a private folder kept locked in a filing cabinet in Uhler Hall.

Once data collection was completed, hypotheses one was tested via simple regression analyses. Independent variables from the EF domain of Inhibition (as measured by the Stroop Color-word Test, the Go/No-Go task and the CPT) were entered into simple regression to predict

the FFMQ facet of Nonreactivity. Next, independent variables from the EF domains of Switching (as measured by the WCST and the IGT) and Updating (as measured by the *N*-Back task and Digit Span task) were entered into separate simple regression analyses to predict the Observe and Acting with Awareness facet subscales of the FFMQ.

The remaining hypotheses were tested via hierarchical multiple regression analyses. To test hypotheses two through four, a series of exploratory analyses were performed examining correlational relationships among the multifaceted constructs of EF, mindfulness, and impulsivity and their associations with emotional control. To test hypothesis two, multiple regression was performed to examine the association between each of these EF factors for predicting performance on the IGT. Two additional regression analyses were then performed to test each of the EF factors for predicting performance on the reappraisal subscale of the ERQ and the suppression subscale of the ERQ. Hypothesis three was tested by entering each of the five facets of mindfulness on the FFMQ into multiple regression analyses to predict IGT performance, responses on the reappraisal subscale of the ERQ and responses on the suppression subscale of the ERQ. To test hypothesis four, multiple regression analyses were run for the five facets of mindfulness to predict IGT performance, the reappraisal subscale of the ERQ and the suppression subscale of the ERQ. Hypothesis four was similarly tested by entering results of the five facets of mindfulness on the FFMQ for predicting each of the impulsivity subscales of the UPPS-P.

Hypothesis five was also tested via multiple regression analyses. First, independent variable measures used in the study were entered into a regression analysis following a stepwise fashion to examine their differential utility for prediction alcohol use. Demographic data including sex, age, race, and academic status were entered as the first step. The five independent

objective performance measures of EF, which include the WCST, Stroop Color-Word Test, *N*-Back, Go/No-Go, and Digit Span task were entered as the second step. Next, scores on FFMQ subscales were entered as the third step, followed by scores on the ERQ and IGT as the fourth step. Lastly, to explore the possible function of impulsivity as mediating the relationship between mindfulness and alcohol use, the scores of the five subscales of the UPPS-P and the CPT were entered as the fifth and final step for predicting alcohol use, as measured by the DDQ-R. For the second hierarchical regression analysis, this sequence was repeated to examine the predictive utility of the previously listed independent variables for predicting alcohol related problems, as measured by the RAPI.

CHAPTER III

RESULTS

Introduction

The aim of this study was to examine the precise nature of the relationships and predictive utility among several measures of executive functioning (EF; i.e. Shifting, Inhibition, and Updating), mindfulness, emotional regulation and decision making, impulsivity, and alcohol use. To empirically study these relationships, several hypotheses were proposed. First, it was predicted that the three basic EF abilities derived by Miyahke and colleagues (2002) would correlate with the five facets of mindfulness. Specifically, Nonreactivity and Nonjudgment would be most related to inhibition, whereas Observing, Acting with Awareness, and Describing would be most related to monitoring and set shifting capabilities. Second, it was predicted that better EF performance would predict better emotion-based decisions and adaptive emotional responding. Third, it was predicted that higher levels of trait mindfulness would correspond with higher levels of adaptive emotional responding and emotion-based decision making, with Observing and Nonjudgment facets being the best predictors of emotion based decision making. Fourth, it was predicted that lower levels of impulsivity on the UPPS-P impulsive behavior scale would be associated with higher levels of mindfulness on the Five Facet Mindfulness Questionnaire (FFMQ). Fifth, it was predicted that better EF performance, higher trait mindfulness, better adaptive emotional responding, and lower impulsivity would correspond with lower levels of alcohol consumption. Finally, it was predicted that better performance on tests of EF, higher trait mindfulness, adaptive emotional responding, and lower impulsivity would also correspond with lower levels of alcohol related problems.

Demographic Results

A total of 155 college students participated and ranged in age from 18 to 23, with the majority of the sample falling between ages 18 and 20. Most participants were also female, white and in their freshman year. Of the total sample, 141 participants correctly completed the alcohol consumption measure; 49 students reported no alcohol use (35%) and 92 students reported at least one drink during a typical week (65%). Of those reporting alcohol use, 72 students reported drinking more than three drinks in a typical week (51%). Due to the overall homogeneity of the sample in regard to ethnicity and academic status, meaningful distinctions among differing racial and academic status variables could not be evaluated. A full account of participant demographic data, including reported alcohol consumption and reported alcohol related problems by demographic variable is included in Table 1. Mean scores for participant performance on EF tasks were comparable to the performance of healthy participants in the normative samples for EF tests where mean scores were reported for the appropriate age range; these test included the WCST (Rhodes, 2004) and the Stroop task (Golden & Freshwater, 2002). Descriptive statistics for participant performance on neuropsychological measures used in the study are reported in Table 2.

Table 1

Descriptive Statistics for Demographic Variables, Alcohol Consumption, and Alcohol Related Problems

Variable	DDQ-R				RAPI			
	Percentage/ Frequency	Range	<i>M</i>	<i>SD</i>	Percentage/ Frequency	Range	<i>M</i>	<i>SD</i>
Age								
18	34.27 (49)	0-24	5.08	6.62	35.94 (55)	0-12	2.16	3.21
19	40.56 (58)	0-28	5.94	7.58	39.22 (60)	0-20	2.58	4.26
20	14.69 (21)	0-34	11.57	11.01	13.73 (21)	0-17	4.57	4.68
21	4.90 (7)	0-21	6.86	8.36	5.23 (8)	0-10	3.13	3.48
22	4.90 (7)	0-60	17.14	20.05	4.58 (7)	0-19	6.71	6.18
23	0.07 (1)	8	8.00	-	1.31 (2)	0	0.00	0.00
Total	100 (143)	0-60	6.99	9.19	100 (153)	0-20	2.89	4.13
Sex								
Male	35.42 (51)	0-34	9.90	10.06	35.52 (54)	0-19	2.83	4.18
Female	64.58 (93)	0-60	5.51	8.36	64.47 (98)	0-20	2.95	4.13
Total	100 (144)	0-60	6.99	9.19	100 (152)	0-20	2.89	4.13
Academic Year								
Freshman	74.31 (107)	0-28	5.85	7.22	75.70 (115)	0-20	2.63	3.90
Sophomore	15.97 (23)	0-34	10.36	11.38	15.10 (23)	0-17	4.09	4.64
Junior	6.94 (10)	0-21	7.30	7.67	6.60 (10)	0-19	3.50	5.78
Senior	2.78 (4)	3-60	20.00	26.94	2.60 (4)	0-6	2.50	3.00
Total	100 (144)	0-60	6.99	9.19	100 (153)	0-20	2.89	4.13
Race								
White	75.70 (109)	0-60	7.79	9.59	75.16 (115)	0-19	2.76	3.78
Hispanic	2.10 (3)	0-5	2.00	2.74	2.61 (4)	0-3	0.75	1.50
Black	14.58 (21)	0-30	5.41	7.74	14.38 (22)	0-17	3.18	4.87
Asian	4.86 (7)	0	0.00	0.00	5.23 (8)	0-20	4.63	6.93
Mid-Eastern	0.69 (1)	1	1.00	-	0.65 (1)	5-5	5	-
Other	2.08 (3)	0-5	1.67	2.89	1.96 (3)	0	0	-
Total	100 (144)	0-60	6.99	9.19	100 (153)	0-20	2.89	4.13

Note. Daily Drinking Questionnaire-Revised (DDQ-R) Rutgers Alcohol Problem Index (RAPI) is measured in units of total drinks consumed in a typical week.

Table 2

Descriptive Statistics for Performance on Neuropsychological Measures

	<i>N</i>	Range	Minimum	Maximum	<i>M</i>	<i>SD</i>
WCST	153	84.00	0	84.00	8.71	7.09
Stroop	152	25.00	3	28.00	25.00	3.63
CPT	153	1.03	0.00	1.03	0.04	0.10
N-Back	152	8.11	-5.33	2.78	-0.54	1.60
Go/No-Go	153	0.73	0.00	0.73	0.04	0.11
Digit Span	153	10.00	7.00	17.00	12.03	2.02
Iowa	153	56.00	-40.00	52.00	2024.84	1023.61

Note. WCST= Wisconsin Card Sort Test; FFMQ = Five Factor Mindfulness Questionnaire; ERQ = Emotional Response Questionnaire; IGT = Iowa Gambling Task; UPPS-P = UPPS-P Impulsive Behavior Scale; CPT = Continuous Performance Task.

Reliability of Self-Report Measures**UPPS-P**

Calculation of the Cronbach's alpha for participant responses to the UPPS-P coincided with previous estimates (Cyders et al., 2007) and showed good internal consistency for the overall scale ($\alpha=.86$). Acceptable to excellent internal consistency was also observed for all subscales: Negative Urgency ($\alpha=.90$), Premeditation ($\alpha=.78$), Perseverance ($\alpha=.79$), Sensation Seeking ($\alpha=.82$), and Positive Urgency ($\alpha=.93$).

FFMQ

Participant responses to the FFMQ fell within the expected ranges established by prior research (Siegle & Petrides, 2014) and showed good overall internal consistency ($\alpha=.83$). Acceptable to good internal consistency was also found in all subscales: Observe ($\alpha=.76$), Describe ($\alpha=.87$), Act with Awareness ($\alpha=.87$), Nonjudgment ($\alpha=.89$), and Nonreactivity ($\alpha=.77$).

ERQ

Internal reliability coefficients for the ERQ corresponded with previous research (Gross & John, 2003) and were acceptable for both the Reappraisal scale ($\alpha=.76$) and the Suppression scale ($\alpha=.75$).

RAPI

Participant responses to the RAPI yielded good internal consistency ($\alpha=.83$) in accordance with past research (Vaughn, Corbine & Fromme, 2009).

Examination of Hierarchical Regression Assumptions

Due to non-normality of the DDQ-R measured variable of total alcoholic beverages consumed in a typical week (skewness = 2.16; kurtosis = 7.34), this variable was transformed using a reciprocal transformation. The new DDQ-R variable approached normality (skewness = .47; kurtosis = -1.66) and was utilized to complete all subsequent regression analyses. Similarly, the results of the RAPI produced a positively skewed distribution, (skewness = 1.68; kurtosis = 3.01) as most students did not report high levels of problems associated with alcohol. The RAPI variable was also transformed using a reciprocal transformation producing a new RAPI variable that approached normality (skewness = -.75; kurtosis = .17). The remainder of the variables showed relatively normal distributions. Visual inspection of partial regression plots for the dependent variable and each of the independent variables in all analyses confirmed the assumption of linearity for the regression models. The Durban-Watson statistic showed independence of residuals for all analyses with all values approaching two. Visual inspection of a plot of studentized residuals versus unstandardized predicted values demonstrated homoscedasticity of residuals for all analyses. Tolerance values were used to assess nonmulticollinearity of variables, and no values exceeded 1.0. Outliers were identified and

removed if studentized deleted residuals were greater than ± 3 standard deviations, leverage values were greater than 0.20, and values for Cook's distances surpassed 1.

Results of Hypothesis Testing

Mindfulness and Executive Function

To explore the relationship between facets of mindfulness and the EF domains of Switching (as measured by the WCST and the IGT), Inhibition (as measured by the Stroop Color-word Test, the Go/No-Go task and the CPT), and Updating (as measured by the *N*-Back task and Digit Span task) a simple regression analysis was performed to test the predictive value of each EF domain for predicting corresponding mindfulness facets. It was predicted that the three basic executive abilities derived by Miyake and colleagues (2000) are necessary for the three facets of mindfulness that are conceptually related to EF to be performed successfully. Specifically, Nonreactivity on the FFMQ would vary with inhibition (Stroop Color-Word Test and Go/No-Go Task), whereas Observing and Awareness would vary with monitoring (N-Back and Digit Span Tasks) and set shifting capabilities (WCST and IGT). This hypothesis was not supported, as no EF domain yielded statistically significant predictions of the expected mindfulness facet. The simple regression model was not significant for the prediction of the mindfulness facet of Nonreactivity based on the EF domain of inhibition (measured by Stroop, Go/No-Go and CPT scores), $R^2 = 0.04$, $F(3,148) = 1.79$, $p = .15$, adj. $R^2 = 0.02$. Regression coefficients and standard errors for the Nonreactivity facet analysis can be found in Table 3. The simple regression model was also not significant for the prediction of the mindfulness facet of Observing based on the EF domains of Updating (measured by *N*-Back and Digit Span scores) and Set-Shifting (measured by WCST and IGT scores), $R^2 = 0.05$, $F(4,147) = 2.01$, $p = .10$, adj. $R^2 = 0.03$. Regression coefficients and standard errors for the Observing facet are found in Table

4. Similarly, the simple regression model was also not significant for the prediction of the mindfulness facet of Acting with Awareness based on the EF domains of Updating (measured by *N*-Back and Digit Span scores) and Set-Shifting (measured by WCST and IGT scores), $R^2 = 0.01$, $F(4, 147) = 0.53$, $p = .72$, adj. $R^2 = -.01$. Regression coefficients and standard errors for the Acting with Awareness facet analysis can be found in Table 5.

Table 3

Simple Regression Analysis for EF Measures of the Inhibition Domain to Predict the Mindfulness Facet of Nonreactivity

Variable	<i>B</i>	<i>SE_B</i>	β
Constant	18.90	2.37	
Stroop	0.09	0.09	0.08
Go/No-Go	6.05	3.34	0.16
CPT	-5.70	3.71	-1.14

Note. $N=151$. $*p < .05$

Table 4

Simple Regression Analysis for EF Measures of the Updating and Set-Shifting Domains to Predict the Mindfulness Facet of Observing

Variable	<i>B</i>	<i>SE_B</i>	β
Constant	27.44	2.56	
WCST	0.07	0.06	0.11
IGT	0.00	0.00	0.15
<i>N</i> -Back	0.32	0.25	0.10
Digits	-0.24	0.20	-0.10

Note. $N=151$. $*p < .05$

Table 5

Simple Regression Analysis for EF Measures of the Updating and Set-Shifting Domains to Predict the Mindfulness Facet of Acting with Awareness

Variable	<i>B</i>	<i>SE_B</i>	β
Constant	24.67	3.13	
WCST	-0.06	0.07	-0.08
IGT	0.00	0.00	-0.07
N-Back	-0.09	0.31	-0.03
Digits	0.14	0.25	0.05

Note. *N*=151. **p*<.05

Executive Function and Emotional Responding

It was predicted that better EF performance would predict better emotion-based decisions and adaptive emotional responding. This hypothesis was not supported. The relationship between facets of EF and emotional regulation and decision making were investigated by regressing EF factors of Switching (measured by the WCST), Inhibition (measured by the Stroop Color-Word Test and Go/No-Go task), and Updating (measured by the N-Back and Digit Span tasks) against performance on the IGT, the ERQ Reappraisal subscale, and the ERQ suppression subscale. The multiple regression model for these EF tasks did not significantly predict performance on the IGT, $R^2 = .03$, $F(1,145) = 0.23$, $p = .79$, adj. $R^2 = -.00$. Regression coefficients and standard errors for the IGT analysis can be found in Table 6. A multiple regression model for predicting adaptive emotional responding, as measured by the ERQ Reappraisal subscale, was also not significant, $R^2 = .06$, $F(1,145) = 1.99$, $p = .14$, adj. $R^2 = .03$. Although the complete model was not predictive of ERQ Reappraisal scores, both the WCST ($p = .05$) and the Digit Span ($p = .05$) tasks significantly contributed to the model. These predictors became non-significant when using the Bonferroni correction to account for the accumulation of error across steps of the analysis, making the new significant *p*-value .01. Although these

results may have been due to type one error, the existence of significant predictors within a model that was not significant overall raised the possibility of multicollinearity. The problem of multicollinearity was reassessed by checking bivariate correlations between each independent variable and the dependent variable. No correlation was higher than $r=.70$. Regression coefficients and standard errors for the ERQ Reappraisal model are reported in Table 7. The multiple regression model for EF also did not significantly predict performance on the ERQ Suppression subscale, $R^2=.02$, $F(1,145)=.50$, $p=.61$, adj. $R^2=-.01$. Regression coefficients and standard errors for the ERQ Suppression analysis can be found in Table 8.

Table 6

Multiple Regression Analysis for the Three EF Factors to Predict IGT Performance

Variable	B	SE_B	β
Intercept	1248.70	815.04	
WCST	22.45	11.91	0.16
Stroop	8.65	23.93	0.03
Go/No-Go	44.61	765.51	0.01
<i>N</i> -Back	-13.69	56.60	-0.02
Digit Span	29.54	43.52	0.06

Note. $N=151$. $*p<.05$

Table 7

Multiple Regression Analysis for the Three EF Factors in Predicting ERQ Reappraisal Subscale Scores

Variable	B	SE_B	β
Intercept	22.68	4.81	
WCST	0.14	0.07	0.16*
Stroop	-0.05	0.14	-0.03
Go/No-Go	-0.15	4.52	-0.00
<i>N</i> -Back	-0.14	0.33	-0.04
Digit Span	0.51	0.26	0.17*

Note. $N=151$. $*p<.05$

Table 8

Multiple Regression Analysis for the Three EF Factors in Predicting ERQ Suppression Subscale Scores

Variable	<i>B</i>	<i>SE_B</i>	β
Intercept	12.49	4.13	
WCST	-0.06	0.06	-0.08
Stroop	0.11	0.12	0.08
Go/No-Go	2.44	3.88	0.05
<i>N</i> -Back	0.22	0.29	0.07
Digit Span	0.09	0.22	0.03

Note. *N*=151. **p*<.05

Mindfulness and Emotional Responding

It was predicted that higher levels of trait mindfulness would correspond with higher levels of adaptive emotional responding and emotion-based decision making, with Observing and Nonjudgment facets being the best predictors of emotion based decision making. This hypothesis was partially supported in that higher trait mindfulness was predictive of emotional suppression but mindfulness was not predictive of emotion-based decision making or adaptive responding. To examine the association between mindfulness and emotion-based responding and decision making, regression analyses were performed to test the predictive value of the five facets of mindfulness for determining scores on the IGT, the ERQ Reappraisal subscale, and the ERQ Suppression subscale. One outlier was removed before regressing the mindfulness facets on the IGT, as examination of this participant yielded a studentized deleted residual greater than ± 3 standard deviations and a Cook's distance above 1. The multiple regression model for the five mindfulness facets did not significantly predict performance on the IGT, $R^2 = .05$, $F(1,147) = .10$, $p = .76$, adj. $R^2 = .02$. Regression coefficients and standard errors for the IGT analysis can be found in Table 9. Likewise, the full multiple regression model for the five mindfulness facets did not significantly predict scores on the ERQ Reappraisal subscale, $R^2 = .24$, $F(1,147) = 2.25$, p

= .14, adj. R^2 = .21; however, FFMQ subscales of Nonreactivity (p =.000), Observing (p =.005), and Describing (p =.025) were found to significantly contribute to the model. Results for Nonreactivity and Observing remained significant after performing the Bonferroni correction (p <0.01). Results for Describing were no longer significant. Regression coefficients and standard errors for the ERQ Reappraisal model are reported in Table 10. Multicollinearity was also assessed by checking bivariate correlations between each independent variable and the dependent variable. No correlation was higher than r =.70. In a departure from these nonsignificant analyses of mindfulness and emotional control, a multiple regression showed FFMQ scores to be significantly predictive of ERQ Suppression subscale scores, R^2 = .20, F (1,147) =5.09, p = .03, adj. R^2 = .20. Nonreactivity (p =.015), Describing (p =.000), and Nonjudgement (p =.026) all contributed to the model at a level of statistical significance. Only the Describing facet remained significant after performing the Bonferroni correction (p <0.01). Regression coefficients and standard errors for the ERQ Suppression model can be found in Table 11.

Table 9

Multiple Regression Analysis for the Five Facets of Mindfulness for Predicting IGT Performance

Variable	B	SE_B	β
Intercept	1488.03	705.79	
Nonreactivity	13.46	20.83	0.06
Observing	35.90	18.39	0.17
Acting with Awareness	1.61	17.75	0.01
Describing	-24.53	16.25	-0.14
Nonjudging	-4.64	14.99	-0.03

Note. N =153. * p <.05

Table 10

Multiple Regression Analysis for the Five Facets of Mindfulness for Predicting ERQ Reappraisal Scores

Variable	<i>B</i>	<i>SE_B</i>	β
Intercept	4.95	3.78	
Nonreactivity	0.35	0.11	0.24*
Observing	0.29	0.10	0.23*
Acting with Awareness	0.04	0.10	0.04
Describing	0.18	0.09	0.18*
Nonjudging	0.12	0.08	0.13

Note. *N*=153. **p*<.05

Table 11

Multiple Regression Analysis for the Five Facets of Mindfulness for Predicting ERQ Suppression Scores

Variable	<i>B</i>	<i>SE_B</i>	β
Intercept	17.29	3.26	
Nonreactivity	0.35	0.10	0.28*
Observing	0.09	0.09	0.08
Acting with Awareness	-0.02	0.08	-0.03
Describing	-0.25	0.08	-0.29*
Nonjudging	-0.16	0.07	-0.20*

Note. *N*=153. **p*<.05

Mindfulness and Impulsivity

It was predicted that lower levels of impulsivity on the UPPS-P would be associated with higher levels of mindfulness on the FFMQ. This hypothesis was partially supported. To examine the associations between facets of mindfulness and facets of impulsivity, analyses were performed to test the predictive value of the five facets of mindfulness to determine scores on the UPPS-P. The multiple regression model for the five mindfulness facets did significantly predict performance on the UPPS-P Negative Urgency Scale, $R^2=0.42$, $F(1,147) = 12.93$, $p = .00$, adj. $R^2 = 0.40$. This result remained significant after performing the Bonferroni correction ($p < .01$).

Regression coefficients and standard errors for the UPPS-P Negative Urgency scale analysis can be found in Table 12. A multiple regression model for predicting UPPS-P Positive Urgency scale scores with the FFMQ was also significant, $R^2 = 0.50$, $F(1,147) = 8.23$, $p = .01$, adj. $R^2 = 0.22$. Again, this result remained significant after performing the Bonferroni correction ($p < .01$). Regression coefficients and standard errors for the UPPS-P Positive Urgency scale analysis can be found in Table 13. Conversely, the multiple regression model for the five mindfulness facets did not significantly predicted UPPS-P Premeditation scores, $R^2 = 0.14$, $F(1,147) = 0.11$, $p = .74$, adj. $R^2 = 0.11$, although the FFMQ Acting with Awareness Scale significantly contributed to the model. The regression coefficients and standard errors for the UPPS-P Premeditation scale analysis are listed in Table 14. The multiple regression analysis for the five mindfulness facets also did not significantly predict participant scores of the UPPS-P Perseverance scale, $R^2 = 0.33$, $F(1,147) = 1.11$, $p = .30$, adj. $R^2 = 0.33$. Although the Acting with Awareness ($p = .00$) and Describing ($p = .00$) scales contributed significantly to the model only the Acting with Awareness predictor remained significant after performing the Bonferroni correction ($p = .01$). Regression coefficients and standard errors for the UPPS-P Perseverance scale model can be found in Table 15. Lastly, a multiple regression model for predicting UPPS-P Sensation Seeking scores with the FFMQ was also not significant, $R^2 = 0.09$, $F(1,147) = 1.26$, $p = .26$, adj. $R^2 = 0.06$. The FFMQ Acting with Awareness scale was a significant contributor ($p = .004$) and remained so after the Bonferroni correction was made ($p < .01$). See Table 16 for regression coefficient and standard errors of the UPPS-P Sensation Seeking analysis. Multicollinearity was assessed by via bivariate correlations between each independent variable and the dependent variable for each of the analysis outlined above that did not demonstrate a significant overall model but yielded significant contributing independent variance (i.e. regression tests for the five mindfulness facets

on the FFMQ for predicting UPPS-P Premeditation, UPPS-P Perseverance and UPPS-P Sensation Seeking). No correlation was higher than $r=.70$.

Table 12

Multiple Regression Analysis for the Five Facets of Mindfulness for Predicting UPPS-P Negative Urgency Scores

Variable	B	SE _B	β
Intercept	4.07	0.33	
Nonreactivity	-0.04	0.01	-0.24**
Observing	0.02	0.01	0.14*
Acting with Awareness	-0.04	0.01	-0.36**
Describing	0.01	0.01	0.05
Nonjudging	-0.03	0.01	-0.27**

Note. $N=153$. * $p<.05$, ** $p<.01$

Table 13

Multiple Regression Analysis for the Five Facets of Mindfulness for Predicting UPPS-P Positive Urgency Scores

Variable	B	SE _B	β
Intercept	3.38	0.35	
Nonreactivity	-0.02	0.01	-0.12
Observing	0.01	0.01	0.06
Acting with Awareness	-0.02	0.01	-0.24**
Describing	-0.01	0.01	-0.07
Nonjudging	-0.02	0.01	-0.25**

Note. $N=153$. * $p<.05$, ** $p<.01$

Table 14

Multiple Regression Analysis for the Five Facets of Mindfulness for Predicting UPPS-P Premeditation Scores

Variable	B	SE _B	β
Intercept	2.64	0.26	
Nonreactivity	-0.01	0.01	-0.12
Observing	0.01	0.01	0.07
Acting with Awareness	-0.02	0.07	-0.26*
Describing	-0.01	0.01	-0.14
Nonjudging	0.02	0.01	0.03

Note. N=153. * $p < .05$

Table 15

Multiple Regression Analysis for the Five Facets of Mindfulness for Predicting UPPS-P Perseverance Scores

Variable	B	SE _B	β
Intercept	3.15	0.24	
Nonreactivity	0.00	0.01	-0.02
Observing	-0.01	0.01	-0.11
Acting with Awareness	-0.04	0.01	-0.49**
Describing	-0.01	0.01	-0.20*
Nonjudging	0.01	0.01	0.09

Note. N=153. * $p < .05$, ** $p < .01$

Table 16

Multiple Regression Analysis for the Five Facets of Mindfulness for Predicting UPPS-P Sensation Seeking Scores

Variable	B	SE _B	β
Intercept	2.98	0.36	
Nonreactivity	0.01	0.01	0.09
Observing	0.01	0.01	0.07
Acting with Awareness	-0.02	0.01	-0.23*
Describing	0.01	0.01	0.09
Nonjudging	-0.01	0.01	-0.11

Note. N=153. * $p < .05$

Prediction of Alcohol Consumption

It was predicted that better EF performance, higher trait mindfulness, better adaptive emotional responding, and lower impulsivity would correspond with lower levels of alcohol consumption. To test this hypothesis, a hierarchical multiple regression was performed to determine if the addition of EF, trait mindfulness, emotional responding, and trait impulsivity improved the prediction of alcohol consumption over and above demographic variables of age and sex. The hypothesis was partially supported, in that the inclusion of impulsivity into the full model was predictive in determining alcohol consumption, whereas individual variables of EF, mindfulness, and emotional responding did not add predictive value. Diagnostics performed to detect statistical outliers, high leverage points and highly influential points showed no concerns. Twelve participants were dropped from the analysis using list-wise deletion because they did not complete all measures. Full details of the regression model are provided in Table 17. In model 1, both age and sex were significantly predictive of alcohol consumption in the analysis producing an increase in $R^2 = 0.06$, $F(2,138) = 4.68$, $p = .01$. Men ($M=9.71$, $SD=10.06$) consumed more alcohol than women ($M= 5.51$, $SD=8.36$), and the amount of alcohol consumed tended to increase with age, with students age 20 ($M =11.57$, $SD=11.01$) and 22 ($M = 17.14$, $SD=20.05$) reporting the highest alcohol use. Students in their junior year also reported the highest levels of alcohol use ($M = 20.00$), although they also represented the smallest academic group ($n=4$) and displayed the greatest amount of variation in responding ($SD=26.94$). White students reported the highest rates of alcohol consumption overall ($M = 7.29$, $SD=9.59$) and comprised the vast majority of the sample ($n=109$). See Table 1 for complete demographic results.

The addition of EF measures (WCST, Stroop, CPT, N-Back, Go/No-Go, and Digit Span scores) to the prediction of alcohol consumption (Model 2) were not statistically significant $R^2 = 0.04$, $F(5, 133) = 1.05$, $p = .39$. Adding mindfulness scores on the five indices of the FFMQ also did not contribute significantly to the prediction of alcohol consumption (Model 3), yielding an increase in $R^2 = .05$, $F(3, 130) = 2.31$, $p = .08$. Adding emotional responding and decision making (as measured by the Reappraisal and Suppression subscales of the ERQ and performance on the Iowa Gambling Task) also did not contribute significantly to prediction of alcohol consumption (Model 4), producing an increase in $R^2 = 0.00$, $F(3, 127) = 0.17$, $p = .91$. The full model (Model 5) of gender, age, executive task performance, mindfulness, emotional responding and decision making, and impulsivity (with impulsivity measured by CPT performance and UPPS-P scores) was statistically significant, with increase in $R^2 = .32$, $F(6, 121) = 5.16$, $p < .01$, adjusted $R^2 = .22$. All significant results for the alcohol consumption analysis remained so after making the Bonferroni correction ($p < .01$)

Table 17

Hierarchical Multiple Regression Analysis Using Demographic, Executive Functioning, Mindfulness, Emotional Control, and Impulsivity Variables to Predict Alcohol Consumption (DDQ-R Total Score)

Variable	DDQ-R									
	Model 1		Model 2		Model 3		Model 4		Model 5	
	<i>B</i>	β	<i>B</i>	β	<i>B</i>	β	<i>B</i>	β	<i>B</i>	β
Constant	0.40		0.09		-0.47		-0.49		1.04	
Sex	0.11	0.13	0.12	0.13	0.15	0.17	0.17*	0.19*	0.18*	0.21*
Age	-0.07**	-0.18**	-0.07*	-0.18*	-0.06	-0.15	-0.06	-0.15	-0.05	-0.13
WCST			-0.00	-0.05	-0.00	-0.04	-0.00	-0.02	0.00	0.02
Stroop Task			0.01	0.12	0.01	0.12	0.01	0.12	0.02	0.14
Go/No-Go Task			0.25	0.07	0.22	0.06	0.20	0.05	0.11	0.03
Digit Span Task			0	-0.00	-0.01	-0.02	-0.00	-0.01	0	0.00
<i>N</i> -Back Task			0.02	0.09	0.03	0.10	0.02	0.10	0.03	0.10
FFMQ Observe					-0.00	-0.01	0.00	0.01	0.01	0.11
FFMQ Acting					0.01	0.16	0.01	0.17	-0.01	-0.06
FFMQ Nonreactivity					0.01	0.13	0.02	0.15	0.01	0.06
ERQ Reappraisal							-0.01	-0.07	-0.01	-0.13
ERQ Suppression							0	0.00	-0.01	-0.08
IGT							0	-0.01	0	0.03
UPPS-P Negative Urgency									-0.26**	-0.40**
UPPS-P Premeditation									-0.32**	-0.30**
UPPS-P Lack of Perseverance									-0.00	-0.00
UPPS-P Sensation Seeking									-0.02	-0.02
UPPS-P Positive Urgency									0.08	0.11
CPT									0.18	0.05
R^2	0.25		0.32		0.38		0.39		0.57	
F	4.68*		2.09*		2.20*		1.70		3.02**	
ΔR^2	0.06*		0.04		0.05		0.00		0.17**	
ΔF	4.68*		1.05		2.31		0.17		5.16*	

Note. WCST= Wisconsin Card Sort Test; FFMQ = Five Factor Mindfulness Questionnaire; ERQ = Emotional Response Questionnaire; IGT = Iowa Gambling Task; UPPS-P = UPPS-P Impulsive Behavior Scale; CPT = Continuous Performance Task. $N=141$. $*p<.05$, $**p<.01$

Prediction of Alcohol Related Problems

It was similarly predicted that better performance on tests of EF, higher trait mindfulness, adaptive emotional responding, and lower impulsivity would also correspond with lower levels of and alcohol related problems. To begin, alcohol use and alcohol related problems were strongly correlated at a statistical level of significant ($r=.48, p<.01$). Next, a hierarchical multiple regression was run to determine if EF task performance, trait mindfulness, emotional responding and decision making, and trait impulsivity improved the prediction of alcohol related problems over and above demographic variables of age and sex (as these were the greatest predictors of alcohol use). The analysis partially supported the above hypothesis, in that mindfulness and impulsivity variables were predictive of alcohol related problems, but EF and emotional responding variables were not. One participant was found to be a statistical outlier and was removed from the analysis. Full details of the regression model for alcohol related problems are provided in Table 18. In model 1, neither age nor sex were significant predictors of alcohol related problems, yielding a change in $R^2 = 0.03, F(2,146) = 2.55, p = .08$. Although men in the sample reported higher rates of drinking, men ($M = 2.83, SD=4.18$) and women ($M = 2.95, SD=4.13$) reported similar amounts of alcohol associated problems. Problematic use reported by age tended to vary. Students age 22 represented a small proportion of the sample ($n=7$) but reported the greatest amount of alcohol related problems ($M = 6.71, SD=6.18$), surpassing participants aged 20 who reported the greatest amount of alcohol consumption. Despite students at age 20 and 22 reporting the greatest amounts of problems, Freshman as an academic status reported the highest rates of alcohol problems ($M = 4.09, SD=4.64$). See Table 1 for complete demographic results.

The addition of EF measures (WCST, Stroop, CPT, N-Back, Go/No-Go, and Digit Span scores to the prediction of alcohol related problems (Model 2) did not lead to a statistically significant increase in $R^2 = 0.02$, $F(5,141) = 0.68$, $p = .64$. Whereas traditional measures of EF did not show a significant increase in predictive value, the addition of mindfulness scores on the five indices of the FFMQ did contribute significantly to the prediction of alcohol related problems (Model 3), yielding an increase in $R^2 = .07$, $F(3,138) = 3.77$, $p = .01$. Adding emotional responding and decision making (as measured by the Reappraisal and Suppression subscales of the ERQ and performance on the IGT) did not contribute significantly to prediction of alcohol related problems (Model 4), producing an increase in $R^2 = 0.00$, $F(3,135) = 0.12$, $p = .95$. The full model (Model 5) of gender, age, EF performance, mindfulness, emotional responding and decision making, and impulsivity (with impulsivity measured by CPT performance and UPPS-P scores) was statistically significant, with an increase in $R^2 = .16$, $F(6,129) = 4.8$, $p < .01$, adjusted $R^2 = 0.19$. All significant results remained so after performing the Bonferroni correction ($p < .01$)

Table 18

Hierarchical Multiple Regression Analysis Using Demographic, Executive Functioning, Mindfulness, Emotional Control, and Impulsivity Variables to Predict Alcohol Related Problems (RAPI Total Score)

Variable	RAPI									
	Model 1		Model 2		Model 3		Model 4		Model 5	
	B	β	B	β	B	β	B	β	B	β
Constant	0.06		0.05		0.05		0.05		0.08	
Sex	0.00	-0.07	0.00	-0.07	0.00	-0.06	0.00	-0.07	0.00	-0.07
Age	0.00*	-0.19*	0.00*	-0.20*	0.00*	-0.17*	-0.00*	-0.18*	0.01	-0.14
WCST			0.00	0.06	0.00	0.08	0.00	0.08	0.00*	0.17*
Stroop			0.00	-0.04	0.00	-0.02	0.00	-0.02	0.00	0.00
Go/No-Go			0.00	0.06	0.005	0.07	0.01	0.07	0.00	0.03
Digit Span			0.00	0.07	0.00	0.04	0.00	0.04	0.00	0.03
N-Back			0.00	0.08	0.00	0.10	0.00	0.10	0.00	0.12
FFMQ Observe					0.00	-0.11	0.00	-0.11	0.00	-0.05
FFMQ Acting					0.00	0.23**	0.00	0.22*	0.00	-0.03
FFMQ Nonreactivity					0.00	0.05	0.00	0.04	0.00	-0.01
ERQ Reappraisal							0.00	0.03	0.00	-0.02
ERQ Suppression							0.00	0.01	0.00	-0.07
IGT							0.00	-0.04	0.00	0.00
UPPS-P Negative Urgency									0.00*	-0.27*
UPPS-P Premeditation									-0.01**	-0.30**
UPPS-P Lack of Perseverance									0.00	-0.03
UPPS-P Sensation Seeking									0.00	-0.06
UPPS-P Positive Urgency									0.00	0.02
CPT									0.01	0.12
R^2	0.03		0.06		0.13		0.13		0.29	
F	2.55		1.21		2.03*		1.56		2.77**	
ΔR^2	0.03		0.02		0.07*		0.00		0.16**	
ΔF	2.55		0.68		3.77*		0.12		4.81**	

Note. WCST= Wisconsin Card Sort Test; FFMQ = Five Factor Mindfulness Questionnaire; ERQ = Emotional Response Questionnaire; IGT = Iowa Gambling Task; UPPS-P = UPPS-P Impulsive Behavior Scale; CPT = Continuous Performance Task. $N=150$. $*p<.05$, $**p<.01$

Exploratory Analyses

Additional hierarchical regression analyses was performed to explore the possibility that the lack of normality and subsequent transformation of the DDQR variable obscured meaningful relationships between alcohol consumption and proposed predictors. For this investigation only students reporting alcohol use were included in the analysis ($n=92$). Again it was hypothesized that age, sex, better EF performance, higher trait mindfulness, adaptive emotional responding, and lower impulsivity would be associated with less alcohol consumption. This hypothesis was also not supported when applied to only students reporting use of alcohol. Age and sex remained significant predictors of alcohol use when including only alcohol users $R^2 = 0.07$, $F(2, 89) = 3.38$, $p = .04$; however, these predictors were no longer significant after applying the Bonferroni correction ($p < .01$). Hierarchical models including EF, mindfulness, and emotional responding were also not significant. The full model, which also included impulsivity, was significant $R^2 = 0.42$, $F(6, 72) = 5.46$, $p = .00$. This remained significant when using the Bonferroni correction ($p < .01$). Similar results were found when narrowing the sample to students reporting consumption of greater than three drinks per week ($n=72$). Age and sex were not predictive $R^2 = 0.08$, $F(2, 69) = 3.00$, $p = .06$, and hierarchical models including EF, mindfulness, and emotional responding were also not significant. The full model was significant $R^2 = 0.47$, $F(6, 52) = 4.55$, $p = .001$ when including only heavier users. This full model remained significant after making the Bonferroni correction ($p < .01$). These results show a stronger relationship between impulsivity and alcohol use when abstainers and minimal users are removed from consideration.

Exploratory hierarchical regression analyses were also performed to investigate the predication of alcohol related problems for alcohol consumers. Again it was hypothesized that

EF performance, higher trait mindfulness, adaptive emotional responding, and lower impulsivity would be associated with fewer alcohol related problems. Contrary to the original analysis of alcohol related problems, the addition of mindfulness to the model was no longer predictive of alcohol related problems when including only alcohol users $R^2 = 0.19$ $F(3,81) = 1.09$, $p = .36$. The full model, which included impulsivity, was also not statistically significant $R^2 = 0.32$, $F(6, 72) = 2.09$, $p = .06$. Similar results were found when narrowing the sample to students reporting consumption of greater than three drinks per week ($n=72$). Hierarchical models including age, sex, EF, mindfulness, and emotional responding were not significant. The full model was also not significant $R^2 = 0.41$, $F(6,52) = 1.72$, $p = .13$ when including only heavier users.

CHAPTER V

DISCUSSION

This study sought to investigate the relationships among executive functioning (EF), mindfulness, and alcohol use for the purpose of informing clinical assessment and intervention. Despite the well-known risks of alcohol abuse and the subsequent persistent efforts to curtail problematic alcohol consumption among college students, high rates of drinking have continued (SAMSHA, 2013; Hingson, 2010). Relevant literature has documented associations among EF (Bolla, Funderburk, & Cadet, 2000; Fishbein et al., 2007; Goldstein, & Volkow, 2011; Fernandez-Serran et al., 2010), mindfulness (Fernandez, Wood, Stein, and Rossi, 2010; Eisenlohr-Moul, Walsh, Charnigo, Lynam & Baer, 2012), and alcohol abuse; however, the exact nature of these relationships and the predictive utility of existing measures of the EF and mindfulness for assessment and treatment has remained incomplete. It is known that both EF and mindfulness are predictive of alcohol use (Bowen et al., 2006), psychopathology (Tang et al., 2012; Murphy & MacKillop, 2011) and poor health behaviors (Hall, Fong, Epp, & Elias, 2008; Mars & Abbey, 2010), but the field has lacked a fuller understanding of the discriminative and additive predictive values of mindfulness and EF for clinical assessment and intervention when considered together. Results of the current study support the use of overall trait mindfulness as a predictor of alcohol related problems, but not alcohol use in general, and not in conjunction with objective performance EF tasks. Despite documented similarities between mindfulness and EF and their relationships to alcohol abuse, measures of EF in this study consistently failed to show a relationship to mindfulness or predictive utility for both alcohol use and alcohol related problems.

Mindfulness and EF share many commonalities including a multifaceted structure, state and trait like characteristics, and associations with the frontal lobes. EFs have been defined as integrative, higher order cognitive processes associated with the prefrontal cortex (Jurado & Russell, 2007 and Lezak, 2012). Prior work has shown the EF domain to be comprised of distinct, yet interrelated components including Switching, Inhibition, and Updating abilities (Miyake & Friedman, 2012). While this work is recent and provides a useful framework for understanding the complex nature among varying EF abilities, it is not the only theoretical view of the EF construct. Baddeley and Hitch (1974) have defined EF as a “central executive” subcomponent of a broader working memory process. According to Baddeley (1998) EFs also show trait stability within individuals assessed across time (Barkley, 1997; Giancola & Tarter, 1999; Biederman et al., 2007) including consistent performance on multiple EF measures in people from preadolescence through adulthood (Tarter et al., 2003). Norman and Shallice (1986) have viewed EF as a piece of an overall Supervisory Attentional System (SAS) that separates into automatic and controlled processes rather than a collection of distinct yet interrelated abilities. To add further complexity, Lezak has alternatively defined EF as a cognitive process of behavioral expression that includes goal formation, planning, execution, and performance monitoring. It should be noted that utilizing any one of these alternative theoretical conceptualizations of EF, and different measures of EF, may yield different results regarding relationships among EF, mindfulness, and alcohol usage than those demonstrated in this investigation. Regarding measures, prior studies of EF found associations between binge drinking and the Cambridge Neuropsychological Tests Automated Battery (Hartley, Elsabagh & File, 2004; Weissenborn & Duka, 2003), the Vigilance task from the Gordon Diagnostic System

and (Townshend & Duka, 2005) and the Spatial Working Memory Task (Weissenborn & Duka, 2003). Within the context of the field's current knowledge, further study of particular tests and theoretical models is greatly warranted.

Just as EF escapes a widely accepted definition and theoretical framework, mindfulness is similarly abstract. For the purpose of most modern studies, mindfulness has been defined as purposefully paying attention to the present moment while withholding judgment (Kabat-Zinn, 2003; Bishop et al., 2004). Mindfulness as a multifaceted construct has been supported through work by Baer and colleagues (2006) by exploring the factorial structural of existing self-report measures of mindfulness. This work yielded five component factors: (1) Nonreactivity, (2) Observing (3) Acting with Awareness, (4) Describing, and (5) Nonjudging. When examining mindfulness as a trait it can then be understood as habitually being in a state of mindful awareness that varies in frequency, duration, and intensity among individuals (Brown, Ryan, Loverich, Biegel & West, 2007; Brown & Cordon, 2009; Glomb, Duffy, Bono & Yang, 2011). Both EF and Mindfulness have shown biological commonalties including levels of cortical thickness and activation in frontal lobe regions (Hölzel et al., 2011). Notably, studies of mindfulness show increased activity and cortical thickness in the frontal lobe regions of the ventromedial prefrontal cortex (Creswell et al. 2007), ventrolateral prefrontal cortex (Owen, McMillan, Laird, & Bullmore, 2005), and the Anterior Cingulate Cortex (Tang et al., 2012).

Expanding beyond general links between prefrontal substrates and mindfulness practice, studies have documented relationships among mindfulness, EF, and alcohol use. Black, Semple, Pokhrel and Grenard (2011) showed significant and large effects between mindfulness practice, general alcohol consumption, and AUDIT scores. Similar to the current study, their examination

showed shared variance between trait mindfulness and self-control. Interestingly, the connection between working memory and self-control was also significant, but there was no significant relationship between mindfulness and working memory, further suggesting that impulsivity may be a key variable in linking mindfulness, EF, and alcohol use. The assessment modality may also play a key role. Lyvers, Makin, Toms, Thorberg, and Samios (2014) showed trait mindfulness to be related to all three indices of prefrontal cortex dysfunction on the FrSBe (a subjective self-report measure of EF abilities). Based on this finding, the inclusion of a self-report measure of EF in the current study may have yielded different results than the use of entirely objective performance measures.

Hypotheses

Mindfulness and Executive Function

It was predicted that the three basic EFs would be necessary for three of the conceptually linked facets of mindfulness to be performed successfully, with Nonreactivity varying with Inhibition, whereas Observing and Acting with Awareness would vary with Updating and Switching capabilities. This hypothesis was not supported, as no EF domain yielded statistically significant predictions of the expected mindfulness facets. Although previous research has shown improvements in EF following mindfulness training, including improvements in attention and neurological operations (Tang et al., 2012) and improved Stroop task performance (Teper & Inzlicht, 2013), this investigation did not yield evidence of associations between mindfulness and EF. The use of neurologically healthy, college-aged students may partially explain this, as many existing measures of EF were originally designed not to measure a range of continuous neuropsychological abilities but to detect neuropsychological deficits (Lezak, 2012). Given the

documented connection between EF and mindfulness training, it is also possible that enhances in immediate EF task performance are limited to utilizing state mindfulness practices. Future research should investigate this possibility; however, the overall failure to find significant relationships between EFs and mindfulness facets through the course of this study suggests that EF and mindfulness are separate constructs.

Executive function and Emotional Responding

It was predicted that better EF performance would predict better emotion-based decisions and adaptive emotional responding based on the theoretical framework provided by the Affect Alarm Model of Self-Control (AAM) and the Somatic Marker Hypothesis (SMH). This hypothesis was not supported. The AAM argues for the preeminent position of emotion as a conflict cue that warns of imminent goal failures, instigating EF processes for the purpose of enacting adaptive behavioral actions. The SMH argues that dysfunctional decision making results from an inadequate use of emotion-based signals produced by the body (“somatic markers”) to inform behavior. The AAM and SMH are built on the premise that EF abilities are greatly influenced by signals stemming from the neural substrates of emotion in the ventromedial prefrontal cortex (vmPFC) (Dunn, Dalgleish, & Lawrence, 2006). Previous work by Damasio (1994), Quirk, Likhtik, Pelletier, & Pare (2003) and Sotres-Bayon & Quirk (2010) on the vmPFC showing its role in integrating emotion, control, and behavior via a top-down inhibition of amygdala activity also suggested a link between EF, emotional responding, and decision making. Given much of the prior work on the vmPFC was done with individuals with neurological impairment (Damasio, 1994), personality disturbances (Barrash, Tranel, & Anderson, 2000), disorders of mood (Price, 1999; Anand et al., 2005), post-traumatic stress disorder (Milad et al.,

2009), anxiety (Myers-Schulz & Koenigs, 2012), and schizophrenia (Holt et al., 2009), such findings may not generalize to differences in EF among healthy participants. This combined with the failure of EF measures to significantly predict multiple dependent variables across the study (i.e. mindfulness facets, alcohol use, and alcohol related problems) may also explain the study's inability to detect connections between EF and emotional responding and decision making.

Although the complete model including all EF measures was not predictive of emotional responding, the WCST and Digit Span tasks did significantly contribute to the model. Throughout the study there were several multiple regressions analysis models that were not significant overall, but which had independent variables that showed significant contributions. One possible cause for this is multicollinearity; however, subsequent analysis ruled-out this possibility. Other contributing factors include small sample size and the inclusion of too many independent variables. Because multicollinearity was not found to be problematic, results of all analyses yielding overall insignificant were treated as nonsignificant.

Mindfulness and Emotional Responding

It was predicted that higher levels of trait mindfulness would correspond with higher levels of adaptive emotional responding and emotion-based decision making, with Observing and Nonjudgment facets being the best predictors of emotion based decision making. This hypothesis was partially supported; higher trait mindfulness was not predictive of emotion-based decision making or adaptive responding, but mindfulness was predictive of emotional suppression.

The hypothesized connections among EF, mindfulness, and alcohol use may be better understood via the theoretical scaffolding provided by the Affect Alarm Model of Self-Control (AAM; Inzlicht and colleagues, 2013) and the Somatic Marker Hypothesis (SMHJ; Damasio, 1994). In the AAM, Inzlicht, Bartholow and Hirsh (2015) argue for the preeminent position of awareness of aversive emotional states as vital components of executive control. This process begins with a standard that is monitored via feedback mechanisms to detect deviation from a predetermined set-point. If current circumstances conflict with the set-point, anxiety is elicited, triggering EFs and self-control behaviors to resolve the conflict. Under this model, emotional experience and sensitivity is essential for EF, thus this study hypothesized that higher rates of emotional acceptance and lower rates of emotional suppression would be associated with better EF functioning.

Whereas the AAM focuses on monitoring aversive emotional states (e.g. anxiety) to instigate EF, the SMH is somewhat broader in scope and encompasses learning theory and physiological feedback loops as mechanisms for eliciting behavioral responses. The SMH views behavioral control as the result of learned neurological and cybernetic associations among sensory data, emotional experiences, and physiological responses that have been integrated by the prefrontal cortex (Damasio, 1994). These associations serve as “somatic markers” and enable organisms to utilize prior learning to inform rapid and adaptive decision making by labeling emotion laden sensory information as especially salient. It was out of this theory that the IGT was developed (Bechara et al., 1994) as a measure of adaptive responses based on visceral emotional responses to environmental feedback. Because the SMH proposes that adaptive behaviors result from emotionally informed decision making, this study hypothesized

that better IGT performance would be associated with less drinking behavior and fewer alcohol associated problems; however, no such relationship was found.

Mindful acceptance of distressing emotions encourages a nonjudgmental attitude and mitigates the need for cognitive emotional avoidance (Teper et al., 2013) to foster adaptive behavioral responding (Williams, 2010). This literature is consistent with the study's finding that mindfulness predicts emotional suppression, in that those reporting higher levels of trait mindfulness are less inclined to report use of maladaptive emotional suppression strategies. These results make sense, in that individuals reporting higher levels of emotional acceptance will also report less emotional suppression. However by the results of this study, heightened mindfulness does not appear to be associated with emotion-based decision tasks (e.g. the IGT) or related to adaptive emotional reappraisal strategies. A possible explanation for a failure to find a relationship between mindfulness and emotional reappraisal is that many of the scale items on the ERQ are worded in a way to suggest purposefully changing interpretations as a means of decreasing aversive emotional states. Such a strategy, while possibly helpful, is inconsistent with a mindful approach that includes acceptance and nonjudgment. Regarding IGT performance, previous research by Lakey, Campbell, Brown, and Goodie (2007) showed a significant relationship between mindfulness (as measured by the MAAS) and the IGT among problem gamblers. This suggests a link between mindfulness and IGT is present, but this may be a function of the measures used or the population under study. Previous studies have shown decreased performance on the task among abusers of alcohol (Bechara et al., 2001) and several other substances (Verdejo-Garcia & Bechara, 2009), but the task may be less sensitive to differences within a healthy, college population.

Mindfulness and Impulsivity

Whereas impulsivity is rooted in a strong present-moment urge to act without regard to future consequences, the present-centered aspect of mindfulness is thought to halt reactive behavior. When investigating the role of both mindfulness and impulsivity, Murphy and MacKillop (2012) found that the relationship between mindfulness and alcohol use was completely mediated by impulsivity. Their investigation found highly variable relationships between the constructs, implying the traits were distinct but related in a reciprocal manner. Presently, it was predicted that lower levels of impulsivity on the UPPS-P would be associated with higher levels of mindfulness on the FFMQ. This hypothesis was partially supported, as mindfulness scores were predictive of some aspects of impulsivity and not others.

The present study found a strong relationship between the all facets of the FFMQ and negative urgency (42 percent of the variance explained by the full model) and a strong relationship between all facets of the FFMQ and positive urgency (50 percent of the variance explained), supporting the hypothesis that higher levels of the mindfulness trait are associated with fewer impulsive behaviors under strong negative and positive mood states. Mindfulness scores were not predictive of scores on the premeditation scale of the UPPS-P, although Acting with Awareness scores on the FFMQ did contribute significantly to the model. The premeditation scale measures an individual's penchant for failing to reflect on consequences of actions before undertaking them. Because mindfulness is the act of present-moment observation without judgment, it follows that it may not be predictive of thoughtful analysis of potential behavioral outcomes. This is because such an analysis represents a future orientation and judgment of hypothetical actions. The Acting with Awareness facet may also have contributed

significantly because it involves behavioral action, whereas the remaining four facets involve observation, nonjudgment, and nonreactivity.

Similarly the FFM-Q did not predict scores on the Perseverance scale of the UPPS-P. The perseverance scale measures difficulty attending to long, challenging tasks. Perseverance, while a useful and adaptive trait, involves purposeful, goal-directed action, not necessarily nonjudgmental awareness. Although the overall model was not predictive, the Acting with Awareness and Describing scales significantly contributed to the model. Both these facets involve action, suggesting the relationship between impulsivity and mindfulness lay within the realm of behavioral action (i.e. doing) rather than observing. To this point, the Acting with Awareness facet of the FFMQ was the only facet to significantly contribute to all models predicting the UPPS-P scale scores. Overall results of the present study suggest mindfulness and impulsivity are reciprocally related but complex and distinct constructs, not simply two sides of the same coin.

Prediction of alcohol consumption

It was predicted that better EF performance, higher trait mindfulness, better adaptive emotional responding, and lower impulsivity would correspond with lower levels of alcohol consumption. This hypothesis was partially supported. The full model containing all variables was statistically significant and highly predictive of alcohol use, explaining 57 percent of the variance. Consistent with existing literature (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2015) age and sex were significant predictors among college students, as older, male students tended to consume more alcohol. Although EF, mindfulness, and emotional control contributed to the overall hierarchical model, their influence did not result in a statistically

significant change above the initial influence of age, diminishing their likely utility as assessment strategies for predicting general alcohol use behaviors. Although robust associations have been found repeatedly between the amount of alcohol use and poorer performance on the Iowa Gambling Task (Fernandez-Serran et al. and Verdejo-García, Pérez-García, Bechara, 2006), no such relationship was found in this study. This is likely due to the population under scrutiny, being participants in the current investigation were young and had only just begun to use or abuse alcohol compared to older adults in general populations investigated by previous researchers.

Importantly, lower impulsivity was predictive of less alcohol consumption and contributed to consistent findings in the existing literature showing a bidirectional relationship in which less impulsivity results in less alcohol use (Dick et al., 2010; Murphy & MacKillop, 2012). A bidirectional relationship between impulsivity has been well established in the literature in that impulsivity both predicts alcohol use (Verdejo-Garcia, Lawrence & Clark 2008) and alcohol abuse results in impulsive behavior (Marczinski, Abrams, Van Selst, & Fillmore, 2005). The study of chronic alcohol abuse and dependence has also shown prolonged abuse leads to emotional and behavioral dysregulation that, in turn, increases impulsive behavior (Koob & LeMoal 1997). What remains unknown is if impulsivity itself results in alcohol related problems or if it is only a piece of the same underlying vulnerability that contributes to alcohol abuse (Dick et al., 2010). The use of healthy young adults in this study demonstrates the connection between impulsivity and alcohol abuse at one segment of the developmental lifespan; however, these results show that this connection is not confined to those who chronically abuse alcohol or meet clinical criteria for dependence. This has important implications for evaluation

and treatment, as high scores on impulsivity measures may identify cases for early intervention before dependence develops.

Past research has also demonstrated that assessing sensation seeking can be useful in identifying users of alcohol and other substances (Meil et al., 2016). Contrary to other past research highlighting the Sensation Seeking scale of the UPPS-P as an independent predictor of alcohol abuse (Magid, MacLean, & Colder, 2007); contributions by the Negative Urgency and Premeditation scales of the UPPSP were the two UPPS-P variables to yield statistically significant contributions to the models in this study. This may simply represent an idiosyncratic finding of this particular sample, but it does suggest the importance of assessing the impulsivity trait as a whole when studying substance use. Overall, findings in this study reinforce the importance of impulsivity as a predictive and contributing factor to alcohol abuse.

Prediction of Alcohol Related Problems

As with total alcohol consumption, it was predicted that better EF performance, higher trait mindfulness, more adaptive emotional responding, and lower impulsivity would be associated with fewer alcohol related problems. This hypothesis was also partially supported. The full model containing all variables was statistically significant and explained 29 percent of the variance. Although men consumed more alcohol, they did not report more alcohol related problems than women, and EF was not predictive of alcohol abuse. It has previously been shown that alcoholics show attenuated grey matter density in the dorsolateral prefrontal cortex, with EF impairments and persistent dysfunction increasing as a function of lifetime alcohol abuse even after achieving abstinence (Chanraud et al., 2007). It may be that EF impairments on objective measures emerge after sustained alcohol abuse, with these results

providing evidence for the perspective that clinically observable EF dysfunctions are the results of alcohol related neurotoxicity, rather than premorbid detriments. A vast literature exists documenting biopsychosocial traits that predict alcohol abuse later in life (Chanraud et al., 2007; Tarter et al., 2003); however, existing objective EF evaluation tasks may be best used as assessment measures later in the developmental course of alcohol abuse.

Consistent with the previous literature, both mindfulness (Fernandez, Wood, Stein, & Rossi, 2010) and impulsivity (Murphy & MacKillop, 2011) were predictive of alcohol related problems. Prior work has linked trait mindfulness to reduced alcohol abuse (Fernandez et al., 2010; Murphy, 2012; Murphy & MacKillop, 2012; Robinson, 2010) and mindfulness-based interventions have shown efficacy in reducing consumption of alcohol (Bowen et al., 2006; Bowen, Witkiewitz, Dillworth & Marlatt, 2007; Bowen et al., 2009; Witkiewitz & Bowen, 2010). Mindfulness has been thought to attenuate many types of substance abuse by improving trigger awareness and serving as a skill for noticing and accepting positive and negative urges while preventing problematic responses (Marlatt et al., 2002). Although the present study did not find strong associations between trait mindfulness and total alcohol usage by college students, the present connection between mindfulness and alcohol related problems found here does support the utility of mindfulness as an assessment and intervention strategy when dealing with alcohol related problems. Adequately distinguishing between alcohol use, and alcohol related problems is important despite similarities between the categories. Alcohol use and alcohol related problems are related, correlating in the present study at a level of statistical significance ($r=.48, p<.01$). This makes sense conceptually, as alcohol consumption is a prerequisite for developing alcohol related problems; however, a differences between the predictive utility of age

and gender (the two largest predictors of alcohol use) in predicting alcohol use vs. alcohol related problems, implies that use and problems are two related but separate constructs.

Limitations

The current study contains limitations related to measurement and sampling. First, while self-report measures were used to assess trait mindfulness, impulsivity, alcohol use, and alcohol related problems, no self-report measures were used to assess EF. Multiple instances have been documented throughout the addiction literature of self-report measures predicting substance use and abuse. For example, Meil et al. (2016) found the FrSBe Disinhibition subscale predicts alcohol, tobacco, and marijuana use, whereas index scores on the Delis-Kaplan Executive Function System did not. Such findings added to previous studies showing FrSBe Disinhibition subscale scores to be related to higher rates of alcohol consumption and increased harmful drinking behavior among college students (Lyvers, Duff, Basch, & Edwards, 2012; Lyvers, Czerczyk, Follent, & Lodge, 2009). Exclusive use of clinical objective EF measures primarily designed for identification of neuropsychological deficits may have obscured more subtle variations in EF abilities among healthy young adults that self-report and ecologically designed measures may have captured. For example, Verdejo-Garcia and Perez-Garcia (2007) found no significant differences in WCST performance between healthy control and substance dependent individuals (SDI), whereas the FrSBe and the Behavioral Assessment of the Dysexecutive Syndrome (a battery designed to assess EF from an ecological perspective) differentiated between control and SDI groups. Future studies should include self-report measures of EF (e.g. FrsBe and the BRIEF) and look for associations between self-report measures of EF and mindfulness.

Because of the complicated nature of the EF, mindfulness, and impulsivity constructs accurate measurement is a both a key challenge for the present study and for future studies. Impulsivity and mindfulness in the present study were captured exclusively by the use of self-report measures. Although self-reports are widely accepted and routinely used in research they rely upon accurate self-awareness and self-reflection. Utilization of performance based or collateral observations measures may have revealed obscured connections among impulsivity, EF, and mindfulness. For example, participant performance on a delay discounting task and impulsivity measures completed by participant's friends may have indicated differing levels of impulsivity than those reported only by participants. It may be that participants with observed impulsive behaviours show corresponding deficits in EF function captured by alternative measures of executive dysfunction (such as the FrSBE or the BREIF) that did not appear with the UPPS-P and objective EF measures.

The complex nature of EF, mindfulness, and the frontal lobes weighs heavily when considering the results and implication of this study. The results failed to identify significant relationships between mindfulness and EF despite neurobiological and conceptual links. The present study conceptualized EF and mindfulness as traits; however, both constructs also demonstrate fluid aspects. An individual performing poorly on an EF measure may be capable of fully executing skills of everyday living that require EF capacities and a person who is generally mindful can be distracted or focused on the past at any given moment. A major difference between mindfulness and EF is the temporal focus. Whereas mindfulness requires a present orientation, EF strongly incorporates future planning. This complexity both within and between these constructs is not easily reconciled and very difficult to measure; therefore it is

very possible these constructs are related but vital information has been lost in the measurement process. For example, one can demonstrate adaptive behaviour by both anticipating future consequences, formulating a plan, and then flexibly shift to a present-focused mindful orientation to observe the results. The flexible and fluid capacities of EF and mindfulness may function very differently in the environment of everyday life than what can be seen using clinical measures in a controlled environment.

It appears similarities between mindfulness and EF occur at a relatively macro level, as the constructs involve the frontal lobes and enactment of restraint; however, the finer elements function sufficiently to distinguish EF and mindfulness. The concept of EF is very broad and it is likely that different locations within the frontal lobes work to execute different elements of EF, whether they are monitoring, inhibition, updating, or another theoretical component of the overall EF umbrella. It is likely that EF is so complex that a distillation to three domains assessed with two measures each is insufficient to capture the true nature of the EF construct. This is most notable in the failure of many EF measures to demonstrate ecological validity, in that many patients performing poorly on objective tests are still able to demonstrate functional capacity at home (Manchester, Priestly, & Jackson, 2004).

The investigation yielded multiple results in which the overall model for predicting dependent variable was not statistically significant but contained statistically significant predictor variables. For example WCST, Digit Span, and the FFMQ scales of Nonreactivity, Observing, and Describing significantly contributed to models predicting ERQ Reappraisal scores. Although these findings were considered to be nonsignificant and may have been an artifact of sample size, it is possible what appears to be a non-finding may be a finding. A future study

should recruit a larger sample size to rule-out the potential effect and narrow the focus of analysis by concentrating on fewer variables for investigation. As a whole, results of this study suggest a finer-scale approach to subsequent studies of EF, mindfulness, impulsivity, and emotional regulations, with the marginally significant findings observed here presenting avenues for a narrowed focus.

Importantly, a large proportion of students reporting any alcohol use also reported consuming at least three drinks per week (72 of the 91 participants endorsing any alcohol use). Rather than a normal distribution, the students sample was polarized. Students tended either to endorse no alcohol use ($n=49$) or use exceeding three drinks per week ($n=72$). Because of this the study sample required a data transformation. Transforming data may have weakened the power of the analysis to reveal significant results and subsequent exploratory analysis further narrowed the sample size. For example, the exploratory analyses in which non users were removed showed impulsivity remained an important predictive variable for both alcohol use and alcohol related problems, but mindfulness was no longer significant. This may be because the mindfulness variable lost variance when including only alcohol users or it may be that a real difference exists between groups of alcohol abstainers and alcohol users. Because of these findings it may be beneficial to conduct studies in which a larger sample of users and non-users are bifurcated and results analyzed separately.

Prior studies have largely investigated EF capacities in individuals at clinical or prolonged levels of polysubstance or alcohol abuse given the profound societal, personal, and health impact of heavy substance use. This study investigated alcohol use in a largely homogeneous college sample, most of whom were white, quite young (freshman and

sophomores under the legal drinking age), and reporting low levels of alcohol consumption and subsequent related problems. It appears the deficits on EF measures documented by studies of heavy users cannot be generalized to all college students, whereas college students who engage in binge drinking behavior show poorer performance on tasks of planning and attention (Hartley, Elsabagh & File, 2004), visuospatial working memory (Weissenborn & Duka, 2003), working memory (Giancola, Zeichner, Yarnel & Dickson, 1996) inhibitory control, and cognitive flexibility (Townshend & Dukay, 2005). This study did not account for binge drinking, rates of drinking, intermittent periods of heavy drinking, or other substances. Previous studies have documented connections between EF marijuana use and tobacco use (Fernandez-Serrano, Perez-Garcia, Schmidt Rio-Valle & Verdejo-Garcia, 2010); therefore, any variability in EF task performance could be attributable to use of substances other than alcohol. If participants report low alcohol use but show poorer EF performance due other substances, this may obscure existing connections between EF and hazardous substance use behaviors. Given the previously documented connection between heavy drinking and EF impairment, future studies should also investigate the roles of binge drinking behaviors and other substance use.

Clinical Implications and Future Directions

The significant relationship between increased trait mindfulness and fewer alcohol related problems supports the use of mindfulness assessment and treatment intervention for problematic alcohol use. Prior research has already shown efficacy of mindfulness intervention for alcohol abuse; the results of this study suggest mindfulness intervention aimed at college students in general may assist in curbing hazardous drinking behavior before such actions reach clinical significance. Assessing mindfulness should also be done in conjunction with measures of

impulsivity (especially measures of negative urgency and premeditation) as all these variables were predictive of alcohol related problems. Given documented connections between impulsivity (specifically the negative urgency and premeditation subscales of the UPPS-P), mindfulness, and alcohol related problems, future studies should examine if both impulsivity and problematic drinking decrease with increasing mindfulness skills, as this may improve the field's understanding of the role of impulsivity in determining alcohol misuse.

The finding that high trait mindfulness scores predict less emotional suppression strategies also supports the use of mindfulness interventions for which emotional suppression and/or avoidance is problematic or pathological (e.g. anxiety disorders), and these findings contribute to existing literature advocating the utility of mindfulness based interventions for such disorders. Although mindfulness was not predictive of emotion-based decision making (i.e. IGT performance) in a controlled setting using one standardized assessment measure, its connection to emotional suppression, negative urgency and positive urgency warrants further study. Future research may investigate if increasing mindfulness facilitates better emotional responding in real-world clinical activities. For example, does increasing mindfulness result in increased approach behaviors during behavioral exposure treatments for anxiety disorders? The affirmative view is already consistent with the underlying theory of mindfulness based interventions (Meuret, Wolitzky-Taylor, Twohig, & Craske, 2012) and results of a preliminary study by Meuret, Twohig, Rosenfield, Hayes, & Craske (2012) has documented benefits of including mindfulness in exposure treatments.

Continuing experimental work can also further clarify the relationship between mindfulness and impulsivity. For example, studying the influence of mindfulness training on the

impulsivity trait by assessing mindfulness, impulsivity, and alcohol use both before and after intervention could show which aspects of impulsivity are impacted by mindfulness training and contribute to understanding of the intervention's clinical significance. Given findings here that alcohol use increases with age among college students, a longitudinal study that applies a mindfulness intervention at the age of highest reported alcohol use (here age 20), and measures outcomes at the age of highest alcohol reported problems (here age 22) against a control group may prove a useful way of evaluating the effectiveness of a campus mindfulness-based alcohol treatment program.

Although this study was unable to document relationships between EF and mindfulness its findings have contributed to existing research and have suggested possibilities for future intervention and study. This investigation supported previously documented connections between impulsivity and alcohol use. The finding that mindfulness is predictive of alcohol related problems also lends support for the clinical utility of mindfulness as an assessment measure for predicting problematic drinking behavior and for its use as an intervention tool for treating alcohol abuse. Additionally, significant relationships between facets of mindfulness and emotional suppression strategies support mindfulness as an intervention tool for clinical situations in which emotional avoidance and emotional dysregulation are contributing factors. Similarly, the strong connections found here between mindfulness and the impulsivity factors of negative urgency and positive urgency support use of mindfulness interventions for addressing impulsive behaviors. This connection is especially important given the large body of research connecting impulsivity with alcohol abuse and related problems. Ongoing research should

continue to refine the use of mindfulness for predicting and treating problematic impulsive behavior and hazardous substance use.

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