Dispositional Factors that Predict Alcohol Consumption in Young Adult Women

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Abstract

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Alcohol consumption and alcohol use disorders significantly contribute to global disease burden, accounting for nearly ten percent of disability-adjusted life years globally (DALY, Whiteford et al., 2013). Alcohol use affects men and women differently, with women being more affected by the health effects of alcohol use (NIAAA, 2011). Yet, there is a dearth of information investigating alcohol use in women (SAMHSA, 2011). The present dissertation project addresses this public health disparity with a systematic review and two empirical research studies. The review (Carroll, Lustyk, & Larimer, 2015) compiles existing scientific contributions on the consumption of alcohol and its relation to the menstrual cycle in women. The first study (Carroll, Ubay, Craft, Larimer, & Lustyk, Under Review) addresses this research disparity by investigating dispositional factors that predict alcohol consumption in young adult women in a laboratory, and the second research study (Carroll & Larimer, Under Review) examines dispositional factors

that predict alcohol consumption in an online survey. Overall, the results of the present dissertation project suggest that menstrual cycle phase has minimal influence on alcohol consumption.

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This dissertation represents only a sliver of the emotional and practical effort that working towards a PhD has required. I am incredibly privileged to be surrounded by an ever-supportive group of people in my personal and professional life. First, and foremost I would like to thank my family. I am ever indebted to my parents Tom and Tracy Carroll. I would not be in a place to dedicate years to my own education if it weren't for the sacrifices that they both made for me, all through my life. I have my mom to thank for teaching me about equanimity, my dad for teaching me about integrity, and both of them for showing me how to laugh at myself. Hanna, I have always looked to you, even though you are younger, as a role model for living life genuinely. Gabe, I am so proud of your efforts to perspective take with those less privileged than yourself. You have always been so generous with your time, which is something I really admire. I would also like to acknowledge the rest of my expanding family, my brother in law Drew, my Grandparents (Don, Corrine, Margaret, Stevie, Pat, Trudy, and Bob), and my aunts, uncles, and cousins, for the love, support, inspiration, and professional guidance they have continuously provided.

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inspiration and deep understanding in you. Ruben, thank you for inspiring me to take journeys. And a big thank you to my support systems in Peru. Jess, thank you for your connection and support- I am glad that we will always have Lima, IX. And thanks to Dustin, for giving me a new perspective on Lima, and deeply enriching my life such that I cannot recall a period when I have been happier. This process has been amazing, but at times painful, and I would not be here without the additional support of (the rest of) my cohort and my lab-mates. And to all my other connections I did not specifically highlight here (e.g., my climbing buddies, surfing partners, running friends) I am so grateful for our time together.

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I am beyond grateful for each area of support that has brought me here. Yet, some processes that have shown me favor are malevolent. Very few people are afforded the privilege I have in life, and I am very aware of this. I have worked hard, but without invisible systems of structural violence that have benefited me I would not be here. Moreover, I would not be so aware of these systems without this education, and people in my life who hold me accountable for my actions. I aim to leverage the system that has lifted me up at the expense of others, in every aspect of my life, to fight for justice and equanimity. Thank you for that opportunity.

Dispositional Factors that Predict Alcohol Consumption in Young Adult Women

Contents

1. General Introduction

1.1 Alcohol Use in Women

Alcohol use and alcohol use disorders are a significant contributor to global disease burden. Alcohol use is estimated to account for nearly ten percent of disability-adjusted life years globally (DALY, Whiteford et al., 2013). More specifically, alcohol use in the United States is estimated to account for upward of 3.5 million DALYS (Rehm et al., 2014). In this case, DALYS represents the gap between the number of healthy years we would expect a person to live, and the years of life lost to death or disability that can be attributed to alcohol use. Moreover, not included in these estimates of disease burden, alcohol use contributes to risk for injury and other chronic diseases (Rehm et al., 2009). Thus, alcohol use is an important public health concern. However, there has been a historical sex bias in alcohol use research, resulting in a dearth of research investigating the etiological factors that contribute to alcohol use in women (SAMHSA, 2011). Therefore, my dissertation project aims to close that gap by considering factors that predict alcohol use in women. I draw on prior research in men, and existing research with women to create a conceptual model of dispositional factors that predict drinking in young adult women. In this introduction I will review important concepts related to alcohol use, which I explore in depth in a literature review of alcohol consumption in women, and two empirical studies of alcohol consumption in women.

1.2 Alcohol Use and the Menstrual Cycle

Given the historical bias against research in women, there are conceptual gaps in what we understand about alcohol consumption in women. As I delineate in my systematic review, in particular, we know very little about how the menstrual cycle

affects alcohol consumption in women (Carroll et al., 2015). The menstrual cycle is typically divided into two phases- the follicular and luteal phases. The follicular phase begins at the first day of menstrual bleeding and is characterized by steady and consistent levels of estrogen and progesterone, with an increase in estrogen just before ovulation. Thus, researchers investigating variables sensitive to fluctuations in hormones often use the mid-follicular phase, before the rise in estrogen occurs, to capture women when progesterone and estrogen levels are moderate and steady. The luteal phase begins at ovulation and ends at the first day of the menstrual period. The luteal phase is characterized by more fluctuation in estrogen and progesterone. Specifically, under normal conditions the late luteal withdrawal of progesterone stimulates menses. Researchers have termed the latter part of the luteal phase, the premenstrual week or the late luteal phase. This portion of the phase is characterized by falling progesterone and estrogen levels, which are primarily responsible for physical and mental premenstrual-symptoms that arise.

The luteal phase is consistently associated with increased stress reactivity in freely cycling women (e.g., Lustyk et al., 2010). Given the intricate relationship between stress and alcohol use (Sinha, 2008), we posit that times of increased stress vulnerability as in the luteal phase may elicit drinking as a means for coping in women. This pattern of stress vulnerability is consistently found in non-human animals, but evidence is mixed on the relationship between cycle phase and alcohol use frequency in human females (Terner & de Wit, 2006), especially with respect to drinking frequency and quantity (e.g., Allen, 1996; Harvey & Beckman, 1985). This is reviewed in depth in my systematic review (Carroll et al., 2015). To briefly summarize this review, discrepancies in cycle phase

effects on alcohol consumption appear to be related to poor and/or varied methodology for estimation of menstrual cycle phase. Thus, the first empirical study, hereafter referred to as the What Women Want study, uses stringent methodology to conduct repeated measures assessments of alcohol consumption and risk for alcohol consumption across the follicular and luteal phase of the menstrual cycle (Carroll et al., Under Review). The second empirical paper, hereafter referred to as the ATLAS project (named after the parent study Assessing Longitudinal Trajectories of Alcohol Use in the US and Sweden), explores the contribution of premenstrual symptoms to alcohol consumption, a different way of targeting this period associated with increased stress reactivity (Carroll & Larimer, Under Review).

1.3 Alcohol Use and the Behavioral Model of Choice

One way to describe the relationships between cycle phase and alcohol is to view them within the context of neurobehavioral regulatory systems. We are continually confronted with situations in which we must give weight to rewarding and punishing stimuli, make predictions about the time and location that we might encounter these stimuli, and take action based on these evaluations (O'Doherty, 2004). In practice, this results in deciding between options that are more immediate, smaller rewards, versus options that are more delayed, but larger rewards. Ideally, there is a balance of two separate regulatory systems: an impulsive system, involved primarily in the valuation of immediate rewards and an executive system, involved primarily in considering and selecting rewards available in the future (e.g., Bechara, 2005). At even the best times, there appears to be a bias in humans for the more immediate, smaller reward (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012). Intuitively, when situations are

less optimal, and stress is high, regulatory systems can become unbalanced and the ability of the executive system to dampen impulsive proclivity becomes an even more strenuous task (e.g., Lempert, Porcelli, Delgado, & Tricomi, 2012). In particular, delay-discounting, a measure of risk-sensitivity requiring participants to make a choice between immediate, smaller and delayed, larger monetary rewards, relates to alcohol use variables in young adults (Bobova, Finn, Rickert, & Lucas, 2009; Kollins, 2003). Individuals with alcohol use disorders (AUD) experience stress and dysregulation of these regulatory systems, which may account for their problem drinking.

Impulsive Systems: Evidence suggests women may respond differently to risky choice as a function of their menstrual cycle phase. Recent neurobiological evidence indicates that cycle phase modulates sensitivity to reward (Sacher, Okon-Singer, & Villringer, 2013). In particular increased sensitivity to monetary reward is found in the mid-follicular phase as compared to the luteal phase of the menstrual cycle (Dreher et al., 2007). However, no study has investigated cycle phase effects on delay discounting and alcohol use in women. One study assessing delay discounting in women controlling for cycle phase found women who completed delay discounting tasks during the follicular phase displayed increased delay discounting as higher doses of alcohol were administered (Reed, Levin, & Evans, 2012). This suggests that as women become more intoxicated they also become more impulsive, but the role of cycle phase in the relation between impulsivity and alcohol use was not assessed. Thus, the What Women Want study addresses this gap, by looking at cycle phase in relation to impulsivity and alcohol use (Carroll et al., Under Review).

Executive Systems: Executive control is a complex cognitive system. It is comprised of several different sub-systems including attention control, cognitive flexibility, inhibitory control, working memory, and higher level cognitive skills such as reasoning.

Cardiac Vagal Control

With respect to the Cognitive flexibility, one important biobehavioral index is cardiac vagal control (CVC; e.g., high-frequency heart rate variability; e.g., Porges, 1995). CVC is a measure of time variance between adjacent R waves (indicative of ventricular depolarization) on the electrocardiogram. With respect to AUD, low tonic (i.e., baseline) CVC is associated with a history of alcoholism (Ingjaldsson, Laberg, & Thayer, 2003). Data on the stability of CVC across the menstrual cycle is somewhat mixed with some studies suggesting no significant difference in R-R variability by cycle phase (Cooke, Ludwig, Hogg, Eckberg, & Convertino, 2002) and others revealing differences in r-r variability such that the luteal phase is associated with lower CVC (Tanaka, Sato, Umehara, & Nishikawa, 2003). Thus, the What Women Want study (Carroll et al., Under Review) investigates the effects of CVC in relation to menstrual cycle phase and alcohol use.

Attention Control

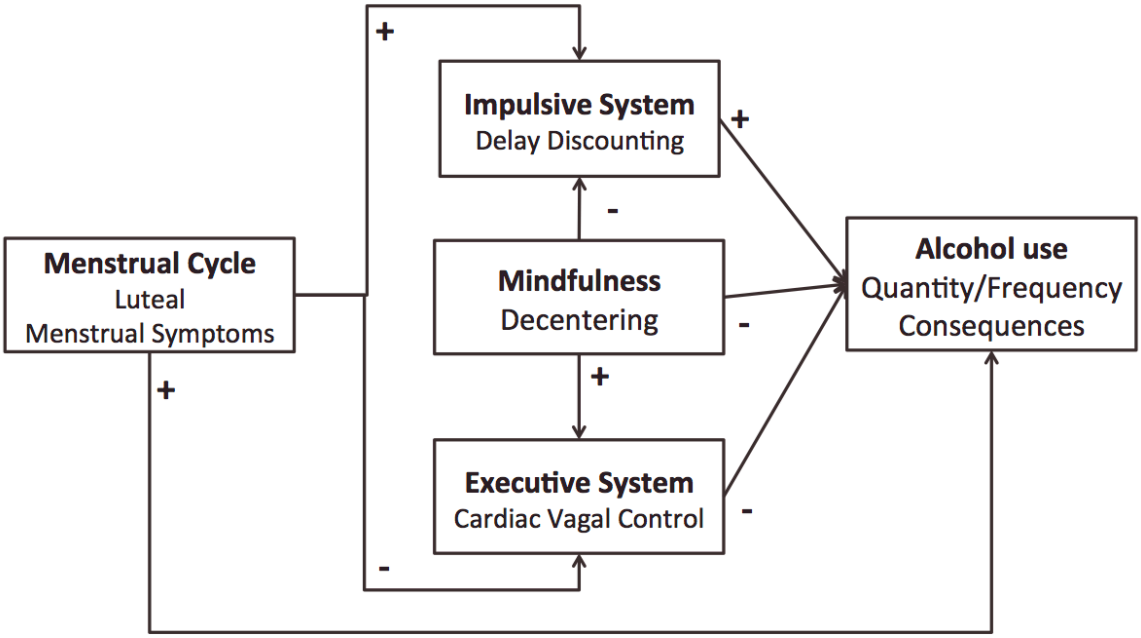
Mindfulness, or the ability to pay attention, on purpose, without judgment to the present moment (Kabat-Zinn, 1990), is one form of attention control. Evidence suggests that mindfulness may be associated with alcohol consumption risk factors as it is associated with impulsive behaviors (Margolin, Beitel, Schuman-Olivier, & Avants, 2006) and increased CVC (e.g., Brewer et al., 2009). Additionally, mindfulness practice is directly related to reduced alcohol use (e.g., Fernandez, Wood, Stein, & Rossi, 2010).

Studies have also investigated the relationship of phasic CVC to stress provocation (i.e., stress induced CVC) in substance use disorders as an index of post-treatment self-regulatory capabilities (Brewer et al., 2009; Garland, Gaylord, Boettiger, & Howard, 2010). Thus, research suggests mindfulness is a deployable skill linked to higher phasic CVC in the face of stress. Mindfulness may therefore moderate the relationship between cycle phase and alcohol consumption, and cycle phase and alcohol risk factors. The What Women Want study (Carroll et al., Under Review) investigates mindfulness as a potential moderator to the relationship between cycle phase and alcohol consumption and alcohol consumption risk factors. The ATLAS project (Carroll et al., Under Review) also examined the relationship between mindfulness and alcohol consumption, but this time looks at the influence of sex and premenstrual symptoms on this relationship.

1.4 Conceptual Model

Figure 2 depicts the conceptual model for the current program of research. Given the public health relevance of AUD and the considerable gap in the extant literature regarding AUD in women, the present dissertation seeks to contribute to our understanding of alcohol consumption among women of reproductive age. Specifically, the present dissertation provides a review of what we know about alcohol consumption related to the menstrual cycle, and presents results of two empirical investigations into alcohol consumption in women. Together these studies investigate the relationships among impulsive and executive decision making systems and the dispositional characteristic of mindfulness in the context of the naturally occurring stressor that arises each month in the lives of healthy, reproductively viable, cis-gendered, freely cycling and post-menarcheal reproductive women.

Figure 2. Conceptual Model



2. The Relationship between Alcohol Consumption and Menstrual Cycle: A review of the literature

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Abstract

Alcohol use affects men and women differently, with women being more affected by the health effects of alcohol use (NIAAA, 2011). Yet, a dearth of information investigating the alcohol use in women exists (SAMHSA, 2011). In particular, one dispositional factor hypothesized to contribute to alcohol consumption in women is the menstrual cycle. However, only 13 empirical papers have considered the menstrual cycle as related to alcohol consumption in women. These studies fall out with somewhat mixed findings suggesting that the premenstrual week is associated with increased, decreased, or no change in alcohol consumption, likely due to methodological differences in menstrual cycle determination and measures of alcohol consumption. These methodological differences and possible other contributing factors are discussed here with recommendations for future research in this area. Understanding the contribution of the menstrual cycle to alcohol consumption is one step in addressing an important women's health concern.

Keywords: Alcohol Consumption; Menstrual Cycle; Women; Women's Health

Women and Alcohol

Alcohol use disorders place a high burden upon society, with estimations of annual public health costs exceeding $223 billion (Bouchery, Harwood, Sacks, Simon, & Brewer, 2011). Although alcohol use disorders have historically been higher in men, recent epidemiological evidence suggests the gap in prevalence of alcohol use and dependence between women and men is decreasing (e.g., Grant et al., 2008). Moreover, men and women face different health risks. For example, women are at greater risk for alcohol related health problems such as liver or heart disease as compared to men (NIAAA, 2011). As such, understanding the underpinnings of alcohol use has become an important women's health issue.

Research has shown that women and men also respond differently to alcohol, specifically, women become intoxicated with lower quantities of alcohol (e.g., Frezza et al., 1990; Mennella & Pepino, 2006). Among individuals who eventually develop alcohol use disorders, women progress more quickly from initial use to abuse than men, a phenomenon called "telescoping." Yet, there has been an overall dearth of research investigating alcohol use in women (SAMHSA, 2011). A recent Institute of Medicine (2010) report indicated existing studies either neglect to include women or fail to account for gender differences. Especially given the occurrence of telescoping, elucidating the etiological factors that uniquely contribute to drinking in women is an important women's health priority in order to effectively inform prevention and treatment programs for women. One such etiological factor hypothesized to contribute to average differential patterns of drinking in women is the menstrual cycle and yet little current and cutting

edge research exists. Thus, our goal is to summarize the state of the science in this area and to offer suggestions for much needed research.

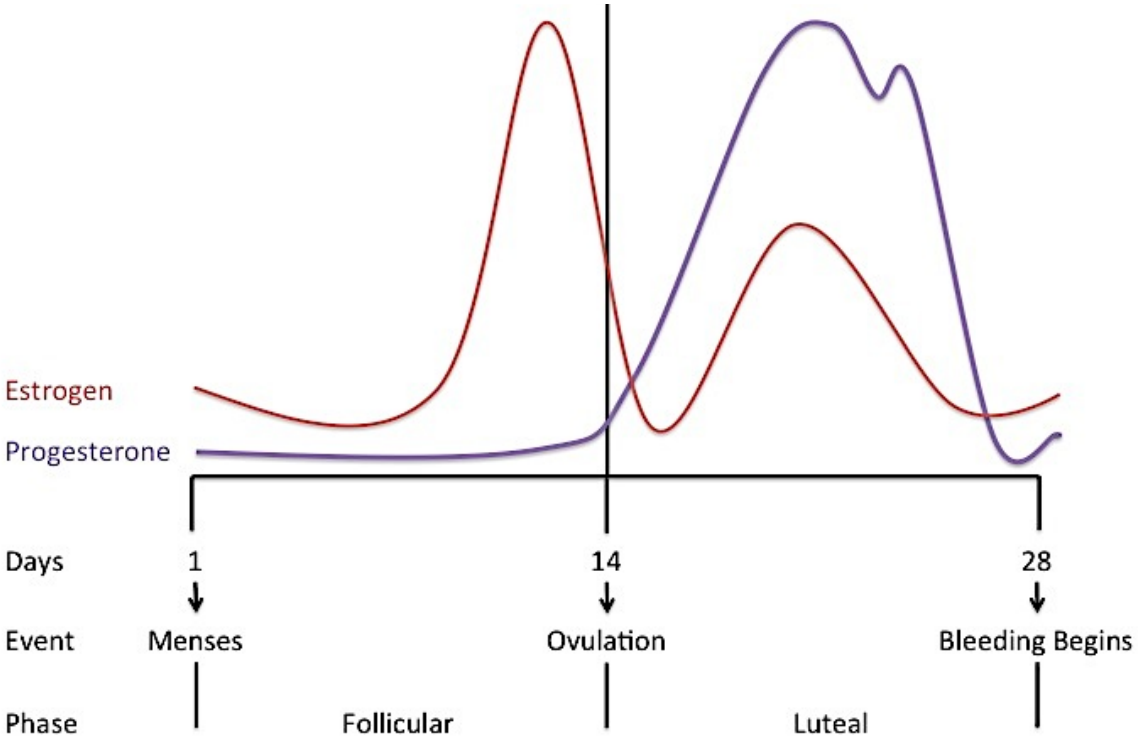
Menstrual Cycle

Endocrine Overview

Myriad reports summarize the endocrinology of the cycle from the classic review by Franz (Franz, 1988) to more recent detailed analyses (Jabbour, Kelly, Fraser, & Critchley, 2006). Menstrual endocrinology may be considered a well-understood part of the scientific canon and as such we offer a brief and relevant overview here (for more information see: Lustyk, Douglas, Shilling, & Reeves, 2014).

Briefly, the menstrual cycle has a frequency of about 21-35 days in reproductively fit women. Broadly defined, it has two phases: follicular and luteal (see Figure 1). The follicular phase begins with the first day of menstrual bleeding (day one of the cycle) and ends with ovulation. The follicular phase is characterized by relatively steady levels of ovarian estrogen and progesterone, with an increase in estrogen just before ovulation. Conversely, the luteal phase follows ovulation and is characterized by rising progesterone and estrogen levels and is the only time during the cycle in which progesterone is unopposed by estrogen. Given the lifespan of the corpus luteum, the luteal phase has a duration of 14+/-2 days.

Figure 1. Menstrual Cycle Phase and Approximate Hormonal Profile of Estrogen and Progesterone



Implications for Research Protocols

To assess women during different cycle phases, researchers apply the above frequency rules. For example, the menstrual period can be easily captured by counting forward from day one of bleeding (e.g., Epstein et al., 2006)), while assessment during a time of relatively steady hormone output can be performed during the mid-follicular phase (i.e., about day 5-7, e.g., Charlette, Tate, & Wilson, 1990). Given that a surge in estrogen and gonadotropic hormones precedes ovulation researchers wishing to capture this time period may employ a pre- or peri-ovulatory window, which can easily be tracked with multitude non-invasive ovulation detection methods allowing for assessments at ovulation (e.g., Griffin, Mello, Mendelson, & Lex, 1987). Once ovulation has been detected, researchers may perform assessments throughout the luteal phase to

study the influence of unopposed progesterone mid-luteal (e.g., Tate & Charlette, 1991) and/or the withdrawal of hormones which occurs during the late luteal phase (i.e., the premenstrual week or 8-12 days after ovulation, (e.g., Pomerleau et al., 1994).

Only recently have researchers begun to study the effects of cycle phase on substance use and abuse as well as treatment acceptance and efficacy (for overview see: Douglas, Shilling, Reeves, & Lustyk, 2013). As a burgeoning area of research, few studies have investigated the variables known to affect alcohol use in women including the menstrual cycle, which may contribute to behavioral changes in alcohol use. One area of focus is negative affect. For example, Lustyk and colleagues (Lustyk, Olson, Gerrish, Holder, & Widman, 2010) have shown that the luteal phase is a time of heightened stress reactivity. Given the intricate relationship between stress and alcohol use (Sinha, 2008), it may be that increased stress vulnerability as in the luteal phase may elicit drinking to cope in women. However, research regarding alcohol consumption and menstrual cycle has been mixed and the remainder of this review will summarize the research to date, paying particular attention to the cycle phase measurement methods employed, and provide a summary of how the data presented may help us understand the underpinnings of menstrual cycle effects on alcohol use.

Early Research on Menstruation and Alcohol Use

Before the mandate to include women in research was made in the 90's, many researchers were excluding women because of the "unstability" of the menstrual cycle phase (Lammers, Mainzer, & Breteler, 1995). Belfer and colleagues (Belfer, Shader, Carroll, & Harmatz, 1971) published an early investigation on the association between menstrual cycle and alcohol use. At that time, virtually no empirical research existed on

the topic, and deductions of a connection between alcohol and menstrual cycle phase posited that the menstrual cycle is disruptive, and disruption leads to drinking.

Since then only a few reviews (Blume, 1986; Lammers et al., 1995; Terner & de Wit, 2006) have outlined research on alcohol use in women by menstrual cycle. Blume (Blume, 1986) provided an early review of alcohol use in women that devoted one paragraph outlining the postulated association of alcohol use and menstrual cycle. More recently, reviews by Lammers and colleages (Lammers et al., 1995) and Terner & de Wit (Terner & de Wit, 2006) focus more specifically on the responses to alcohol across the menstrual cycle.

Lammers and colleagues (Lammers et al., 1995) focus on the pharmacokinetics of alcohol use (or the physiological response to alcohol) in women by cycle phase. They conducted a literature search of articles that: 1) Utilized within subjects design and included freely cycling women; 2) Included appropriate time points of the menstrual cycle to capture significant variations in hormones. In particular, the studies had to compare at least a time when there would be high progesterone and estrogen in the late luteal phase (days 19-25), when there was low progesterone and estrogen in the premenstrual and early follicular phase (days 28-7), and when estrogen was high around the late follicular phase before ovulation (days 9-15)); and 3) Confirmed the occurrence of ovulation by measuring hormones. Only two studies met their criteria. One was a dissertation conducted by King (King, 1984) and the second a study by Sutker and colleagues that resulted in two papers (Sutker, Goist, Allain, & Bugg, 1987; Sutker, Goist, & King, 1987). These studies found that elimination times (i.e., time in min for alcohol levels to reduce from peak blood alcohol content to essentially zero) are higher in

the early follicular phase than in the late luteal phase, and disappearance rates (i.e., rate of change per hour in the slope in the descending limb of the blood alcohol content curve) are higher in the late luteal phase than early follicular phase. In essence, the mid-luteal phase was found to be associated with slightly quicker elimination of alcohol. Given that these studies originate from the same lab and had not been independently replicated, Lammers and colleagues (Lammers et al., 1995) concluded there was no significant evidence to suggest that alcohol pharmacokinetics are altered by cycle phase. Thus, Lammers and colleagues deduced, women should not be excluded from pharmokinetic research on alcohol use. The review by Lammers and colleagues (Lammers et al., 1995) selected studies based on ideal guidelines for methodologically rigorous menstrual cycle research, yet, the literature review was overly restricted and excluded many relevant studies.

An additional review by Terner and de Wit (Terner & de Wit, 2006) outlined the effects of a variety of drugs, including alcohol, across the menstrual cycle and found similar results to the Lammers review. In contrast to the strict criteria of Lammers and colleagues' review (Lammers et al., 1995), Terner and de Wit indicated no criteria for inclusion in their review, but included 13 studies investigating the behavioral and physiological effects of alcohol by menstrual cycle. Of these 13 studies, 8 identified no cycle phase effects on alcohol including studies the pharmokinetics of alcohol by cycle (e.g, Freitag & Adesso, 1993) and the quantity of alcohol consumed by cycle (e.g., Pomerleau et al., 1994). Terner and de Witt (2006) also deliniate early studies that identify cycle phase differences, such as the study conducted by Sutker and colleagues (Sutker, Goist, & King, 1987; Sutker, Goist, Allain, et al., 1987) already reviewed by

Lammer and colleagues. Additionally, three other studies reviewed find menstrual cycle phase differences in relation to alcohol in pharmokinetics and alcohol consumption. Regarding pharmokinetics, Terner and de Witt delineate findings that alcohol pharmokinetics affect women more in the luteal phase. Specifically, plasma levels of ethanol are correlated with anxiety scores in the luteal phase, but not the follicular phase (Logue, Linnoila, Wallman, & Erwin, 1981) and alcohol elimination times are lower mid-luteally and alcohol disappearance rates are higher mid-luteally (Sutker, Goist, Allain, & Bugg, 1987; Sutker, Goist, & King, 1987). Regarding alcohol consumption, Harvey & Beckman (1985) found self-reported alcohol intake is highest in the luteal phase. Given the preponderance of null results, Terner and de Witt (2005) concluded there is no consistent evidence of differential pharmokinetic or behaivioral patterns of alcohol use in humans by menstrual cycle phase.

Although both Lammers and colleagues (1995) and Terner and De Wit (2006) reached similar conclusions, both reviews exclude a great number of studies investigating alcohol use and the menstrual cycle. A more rigorous review, with appropriate scope, is required to outline current findings on alcohol use by menstrual cycle phase. Given the women's health significance of alcohol use in women, it is of interest to identify alcohol consumption in women as related to menstrual cycle. However, no review to date has systematically identified the effects of menstrual cycle phase on alcohol consumption.

Literature review

We searched all current academic articles conducted in human females on "menstrua*" and "alcohol" in PsychInfo and PubMed and found 44 relevant empirical articles on alcohol and menstrual cycle phase. However, we excluded articles that did not

look specifically at alcohol consumption by cycle phase, which left only 13 studies that investigate the relationship between alcohol consumption measured by quantity and/or frequency and menstrual cycle phase (See Table 1).

Table 1. Literature review of the effect of menstrual cycle on alcohol consumption

Reference	Sample			OC	Cycle Phase Determination	OV	No. Cycle	Alcohol Use	Results
	N	Characteristics	% W						
Allen, 1996	48	Healthy		x	Open ended "time of month" you drink?			Self reported increases	33% report Alcohol increase PreM
Belfer et al., 1971	44	34 = alcoholic; 10 = alcoholic husband	97		Self reported patterns of drinking by cycle phase			Self reported increases	67% menstruating, 48% non-menstruating report Alcohol increase PreM
Charette et al., 1990	82	52 = No FH; 30 = FH		x	M: 1 to 3 F: 3 days mid M and OV OV: days 14+/-1 to M L: 3 days mid OV and M Pre-M: -3 to M		2	DD, #, type, setting	No change in alcohol by cycle
Christensen et al., 1989	43	13 = severe PMS, 17 = mild PMS, 13 = no PMS		x	PostM: undefined PreM: undefined		1	DD, daily rating of "more alcohol"	No change in alcohol by cycle
Epstein et al., 2006	12	Women in treatment for alcohol	100	x	M: bleeding Pre-M: -7 to M Other: all other days		1-7	DD, % drink days, mean drinks day	Increased alcohol PreM
Griffin et	30	Regular alcohol	93	x	M: undefined		3	DD, #, type,	No change in alcohol

Reference	Sample			OC	Cycle Phase Determination	OV	No. Cycle	Alcohol Use	Results
	N	Characteristics	% W						
al.,1987		and marijuana users			F: M to OV OV (PeriOV): -14+/-1 to M L: OV to PreM PreM: -3 to M			quantity, not indicated as standard	by cycle
Harvey & Beckman, 1985	69	Healthy	81	x	M: bleeding F: M to OV OV: day BBT drop + 3 days L: OV to PreM PreM: -3 to M	BBT	2-3	DD, # days, absolute alcohol/drink days in phase	Alcohol quantity lowest PreM
Marks, et al.,1994	9	Nicotine smokers with LLPDD	100	x	M: all bleeding days F (PostM): M to OV OV: -16 to -12 to M L (PostOV): -11 to -8 to M PreM: -7 to M		2	DD, alcohol or other drug rating not at all to extreme	Alcohol peak during M
McLeod et al., 1994	54	Generalized Anxiety Disorder, 41 = FH, 13 = no FH	81	x	F: undefined PreM: undefined		1	Self reported increases	FH Increased alcohol PreM
Mello, et al.,1990	14	Regular alcohol users		x	M: 1 to 3 L (Pre-PreM): -5 to PreM		1	30min operant work per drink	Increased alcohol PreM

Reference	Sample			OC	Cycle Phase Determination	OV	No. Cycle	Alcohol Use	Results
	N	Characteristics	% W						
					PreM: -3 to M				
Pomerleau, et al.,1994	22	Regular nicotine smokers		x	M: all bleeding days F (PostM): M to OV OV: -16 to -12 to M L (PostOV): -11 to -8 to M PreM: -7 to -1 to M		1	DD, drinks per day (standard)	No change in alcohol by cycle
Svikis et al., 2006	46	PMS, 17 = FH, 29 = no FH	73		F: 7 days midcyle pre OV Pre-M: -7 days M		2-3	DD, drinks per week	FH Increased alcohol PreM
Tate & Charette, 1991	81	Healthy	100	x	M: 1 to 3 F: 3 days mid M and OV OV: days 14+/-1 to M L: 3 days mid OV and M Pre-M: -3 to M		2	DD, undefined	No change in alcohol by cycle

Note: OC = Oral Contraceptive, indicated if women taking hormonal birth control were excluded; No. Cycle = Number of Cycles Assessed in study; OV = Ovulation; % W = Percent of sample that was White; FH = Family history of alcohol use, paternal side; PMS = Premenstrual Syndrome; LLPDD = Late Luteal Phase Dysphoric Disorder, M = Menstrual Period; F = Follicular Period; L = Luteal Period; Pre-M = Premenstrual Period; BBT = Basal Body Temperature; DD = Daily Diary

Menstruation and Alcohol Consumption

A review of the 13 studies that investigate alcohol consumption by menstrual cycle phase lends three main findings: alcohol consumption increases premenstrually/menstrually; alcohol consumption decreases premenstrually; or there is no change in alcohol consumption by cycle phase. The sample characteristics, methodology around menstrual cycle phase and alcohol use, and the main findings of these studies can be found in Table 1.

Alcohol Consumption Increases Premenstrually/Menstrually

Seven of the 13 studies investigating alcohol consumption by cycle phase find increased premenstrual/menstrual alcohol consumption (Allen, 1996; Belfer et al., 1971; Epstein et al., 2006; Marks, Hair, Klock, Ginsburg, & Pomerleau, 1994; McLeod, Foster, Hoehn-Saric, Svikis, & Hipsley, 1994; Mello, Mendelson, & Lex, 1990; Svikis et al., 2006). Of these studies, two used open-ended self-reported occurrence of drinking during the menstrual cycle to measure alcohol consumption (Belfer, Shader, Carroll, & Harmatz, 1971; Allen, 1996). Belfer and colleagues (1971) assessed alcohol consumption in 34 women with alcoholism and 10 women who had come to the alcohol clinic with their husbands with alcohol use disorders (97% White). No structure is given for the assessment of alcohol use, but Belfer and colleagues reported that 67% of menstruating women and 48% of non-menstruating (retrospective recall) women reported drinking more premenstrually and during the menstrual phase. In a more recent investigation, Allen (1996) asked 48 freely-cycling women (race/ethnicity not reported) what "time of month you drink more," and found that 33% of women reported more alcohol use premenstrually. In combination, these studies provide a broad range for the percentage of

women who reported increases in alcohol use related to the premenstrual period (33%-67%). Additionally, little rigor surrounds the questions posed to women on alcohol consumption or what defines the "premenstrual" period. Thus, these response patterns of women identifying the premenstrual period as more problematic for drinking may be driven by the ethos of social ideas about women and drinking.

Five additional studies found increases in alcohol consumption premenstrually (Epstein et al., 2006; McLeod et al., 1994; Mello et al., 1990a; Svikis et al., 2006) or menstrually (Marks et al., 1994). First, Marks and colleagues (1994) investigated alcohol consumption by cycle phase in 9 nicotine smokers (100% White) with Late Luteal Phase Dysphoric Disorder (LLPDD, now known as Premenstrual Dysphoric Disorder). Alcohol use was measured across 2 menstrual cycle phases using a single self-reported rating of alcohol and other drug use ranging from "not at all to extreme" alcohol or other drug use. In the nitconine smokers with LLPDD, alcohol consumption peaked during the menstrual phase (all bleeding days) as compared to the other menstrual cycle phases (see Table 1).

Two studies looked at family history of alcohol use as a moderator of increased alcohol consumption (McLeod et al., 1994; Svikis et al., 2006). McLeod and colleagues (1994) investigated alcohol consumption by cycle phase in 54 women with Generalized Anxiety Disorder, 41 of whom had a positive family history of alcohol use disorders and 13 of whom had no family history of alcohol use disorders (81% White). Self-reported increase in alcohol consumption was assessed in the follicular (undefined) and premenstrual (undefined) periods of a single menstrual cycle. Results suggested alcohol consumption increased premenstrually for those with a family history of alcohol use only.

Similarly, Svikis and colleagues (2006) investigated alcohol consumption by cycle phase in 46 women with Premenstrual Syndrome, 17 with a positive family history of alcohol use disorders and 29 with no family history of alcohol use disorders (73% White). Daily diary of alcohol consumption, quantified as drinks per week, was kept for between 2-3 menstrual cycles to compare the follicular (the 7 days mid-cycle before ovulation) and the premenstrual period (-7 days to menstruation) alcohol use. Results suggested that alcohol consumption increased premenstrually, again for those with a family history of alcohol use only.

One study, conducted by Epstein and colleagues (2006) compared alcohol consumption across menstrual cycle phases in women receiving treatment for alcohol use. The 12 women (100% White) analyzed in this study came from a larger clinical trial. Alcohol consumption was measured with daily diary entries that yielded percentage drinking days, and mean drinks consumed per day. Results revealed that the premenstrual period (-7 days to menstruation) was associated with more alcohol consumption than the menstrual (bleeding days) or other cycle phases (all other days).

Mello and colleagues (1990) methodology differed from the previously reported studies in that they didn't use self-reported alcohol use, but in vivo operant alcohol procedures to measure alcohol consumption. In this study, 14 female participants who reported regularly using alcohol (race/ethnicity not reported) lived in an experimental laboratory for a month where they could earn alcohol by engaging in operant response tasks (approximately 30min of work per drink). Women completed daily diaries of premenstrual symptoms. Alcohol consumption was compared across the menstrual (day 1-3), late luteal (or as they called it pre-premenstrual period -5 days leading up to the

premenstrual period), and premenstrual periods (-3 days to menstruation). Results suggest that alcohol use premenstrually was related to the premenstrual symptom profiles. Women with no changes in alcohol use across cycles had no premenstrual symptoms, whereas women whose alcohol use increased premenstrually had the highest premenstrual symptoms in areas of emotional wellbeing, and women whose alcohol use decreased premenstrually were highest in symptoms of physical discomfort. Thus, results suggest that alcohol consumption may increase premenstrually in order to cope with negative emotionality during the premenstrual period.

Alcohol Consumption Decreases Premenstrually

In direct contrast to the findings that alcohol consumption increases premenstrually, a commonly cited study by Harvey and Beckman (1985) found decreased alcohol consumption in the premenstrual phase. This study was conducted with exceptional rigor, yet no replication, to date, has supported these findings. Participants in this sample were 69 healthy students and staff at UCLA (81% White), who kept daily diaries for 2-3 menstrual cycles of their alcohol consumption, defined as both number of days that alcohol was consumed and an average alcohol consumption by day by dividing the absolute alcohol by the number of drinking days in each cycle phase. A drop in basal body temperature confirmed ovulation. Alcohol use, defined by number of days of drinking, and absolute alcohol/drinking days in the cycle phase in question (variables used to calculate not reported) was found to be lowest in the pre-mesntrual period (-3 days leading up to menstruation) as compared to other cycle phases (see Table 1).

No Change in Alcohol Consumption by Cycle Phase

An additional 5 studies found no change in alcohol consumption by cycle phase (Charlette et al., 1990; Christensen, Oei, & Callan, 1989; Griffin et al., 1987; Pomerleau et al., 1994; Tate & Charlette, 1991). However, the studies by Charette and colleagues (1990) and Tate and Charette (1991) were conducted on the same sample, so they are discussed in conjunction.

In line with the studies by Belfer and colleagues (1971) and Allen (1996) which assessed self reported alcohol use, Christensen and colleagues (1989) investigated self reported alcohol consumption across the menstrual cycle phase in 43 women, 13 of whom had severe premenstrual syndrome symptomatology, 17 of whom had mild premenstrual symptomatology, and 13 of whom had no premenstrual symptomatology (race/ethnicity not reported). Daily diary of alcohol use, assessed via a rating of if the participant "drank more alcohol," was kept for a complete menstrual cycle. They compared premenstrual (undefined) and postmenstrual (undefined) ratings of alcohol consumption and results revealed no change in alcohol consumption across menstrual cycle phases.

In line with the studies of family history of alcohol use by McLeod and colleagues (1994) and Svikis and colleagues (2006), Charette and colleagues (1990) investigated alcohol consumption in 82 healthy women (race/ethnicity not reported), of whom 52 had a positive family history of alcohol use disorders and 30 had no family history of alcohol use disorders, over 2 menstrual cycles. In an extension of the Charette and colleagues (1990) study, Tate and Charette (1991) analyzed "the same subjects reported on by Charette (Charette et al., 1990), utilizing 81 of the 82 participants reported on in the first paper. Alcohol was assessed by daily diaries of the number of drinks, alcohol type, and

setting where alcohol was consumed. They compared menstrual (days 1-3), follicular (3 days in between menses and ovulation), ovulation (-14+/-1 day to menses), luteal (3 days in between ovulation and menses), and premenstrual (-3 to menses) phases of alcohol use. In sum, Charette and colleagues (1990) and Tate and Charette (1991) found no change in alcohol consumption by cycle phase.

Two studies assessed alcohol consumption in smokers of marijuana (Griffin et al., 1987) or nicotine (Pomerleau et al., 1994). First, Griffin and colleagues (1987) investigated alcohol consumption across the menstrual cycle phase in 30 regular alcohol and marijuana users (93% White). Daily diary of alcohol use, assessed via number of drinks, type of alcohol, and quantity of alcohol use was assessed over 3 menstrual cycle phases. They compared menstrual (undefined), follicular (menstrual to ovulation), peri-ovulatory (-14+/-1 day to menses), luteal (peri-ovulatory to premenstrual), and premenstrual (-3 days to menses) phases of alcohol use and results revealed no change in alcohol consumption across menstrual cycle phases.

Finally, Pomerleau and colleagues (1994) investigated alcohol consumption across the menstrual cycle phases in 22 regular nicotine smokers (race/ethnicity not reported). Daily dairy of alcohol consumption as measured via standard drinks consumed each day was kept for one menstrual cycle. They compared menstrual (all bleeding days), follicular (menstrual to ovulation), ovulatory (-16 to -12 day to menses), luteal (-11 to -8 to menses), and premenstrual (-7 to -1 days to menses) phases of alcohol use and results revealed no change in alcohol consumption across menstrual cycle phases.

Discussion

A review of the literature on the effects of menstrual cycle phase leaves mixed findings. While somewhat inconclusive, there may be justification for the mixed findings including methodological issues. First, there are few studies to draw on for this topic, and it is important to note that several of the studies were conducted out of the same lab, and support similar findings. While this does not negate the findings of the studies, this observation points out overlap in studies conducted within the same lab in theory, methods, and measures that may influence likelihood of obtaining similar results within labs and disparate results across labs.

Next, some of these discrepancies can be attributed to methodological differences in measuring cycle phase. The studies conducted by Allen (1996) and Belfer and colleagues (1971) made no effort to control for or address the definition of cycle phase, so their results could be highly biased by what lay people consider "premenstrual." Three of the remaining 5 studies that found an increased amount of alcohol use in the premenstrual /menstrual phase (Marks et al., 1994; Svikis et al., 2006; Epstein et al., 2006) and only one of the studies that found no change in alcohol consumption (Pomerleau et al., 1994) used the same 7 day window leading up to menstruation to define the premenstrual period. In contrast, the study that found decreased alcohol consumption premenstrually (Harvey & Beckman, 1985), 3 of the 5 studies that found no change in alcohol consumption by cycle (Charette et al., 1990; Griffin et al., 1987; Tate & Charette, 1991) and one of the studies that found increased alcohol consumption premenstrually (Mello et al., 1990) used a 3 day window leading up to menstruation. The remaining several studies did not define what they meant by "premenstrual" and found both increased (McLeod et al., 1994) and decreased (Christensen et al., 1989) alcohol

consumption in the premenstrual phase. Thus, a general trend of a more inclusive window (7 day) being associated with findings of increased alcohol consumption and a shorter window (3 days) being associated with no change, or a reduction, in alcohol consumption emerges. However, there are other methodological variations in these studies, so there may be other contributing factors than menstrual cycle window. While the premenstrual period emerges as the phase of most interest in this literature, the methodology to assess the other cycle phases is important because the other cycle phases are often used as comparisons to the premenstrual period, or even as periods of hormonal stability. Thus, different ideas of what constitutes each cycle phase may capture different hormonal events and contribute to mixed findings.

Moreover, methodological problems in confirming ovulation exist in most of these studies. With one exception (Harvey & Beckman, 1985), no studies made any effort to confirm ovulation. Harvey and Beckman (1985) used a drop in basal body temperature to confirm ovulation. Future studies could test for luteinizing hormone, which stimulates ovulation (TERHLS Group, 1998). It is important to verify ovulation in conducting research relating physical, behavioral, or emotional factors to menstrual cycle phase, because the hormonal profile of anovulatory cycles is markedly different than cycles with ovulation. With an approximate 10% of cycles being anovulatory among free-cycling women, a high number of participants in these studies may have anovulatory cycles that contribute to a different hormonal profile.

Another contributor to changes in progesterone premenstrually is hormonal birth control. In the current review, two studies did not exclude for oral contraceptive use (Belfer, Shader, Carroll, & Harmatz, 1971; Svikis et al., 2006). Both studies that did not

control for oral contraceptives found increases in alcohol consumption premenstrually. However, because the premenstrual hormone levels are possibly altered in these samples, changes in alcohol consumption may not be related to the premenstrual hormonal profile.

In addition to methodological variation in defining cycle phase, the studies reviewed here vary greatly in what is used to define alcohol consumption. Many validated measures of standard ethanol content consumption exist, such as the Timeline Followback (Sobell, Brown, Leo, & Sobell, 1996). However, several studies here used unstandardized open-ended questions about alcohol consumption (Allen, 1996; Belfer et al., 1971; McLeod et al., 1994), single items on measures of alcohol use (Christensen et al., 1989; Marks et al., 1994), or did not specify the constraints around what defined a "drink" (Charette et al., 1990; Tate & Charette, 1991; Svikis et al., 2006; Harvey & Beckman, 1985). Only Pomerleau and colleagues (1994) indicated using standard drinks for calculating alcohol consumption, and they found no change in alcohol consumption by cycle. Mello and colleagues (1990) used particularly unique methods by requiring their participants to live in a laboratory setting where they could earn a "drink" (undefined) by completing 30min of operant work. Their results were somewhat inconclusive, with different premenstrual syndrome symptom profiles predicting differential alcohol consumption by cycle phase (Mello et al., 1990).

Additionally, many of the participant pools used in the reviewed studies contained few participants (e.g., Marks et al., 1994), used convenience samples of college students (e.g., Harvey & Beckman, 1985), and did not report race or included entirely white samples (e.g., Tate & Charette, 1991; Epstein et al., 2006). The study with the highest number of participants was conducted by Charette and colleagues (1991) with 82

participants, who at least 81 of whom were Caucasian (race not reported in Charette et al., 1991, but 100% of the 81 participants in Tate & Charette, 1990 were Caucasian). One study by Marks and colleagues (1994) had only 9 participants, who were also all Caucasian. While Harvey and Beckman (1985) used fairly stringent methodology, their sample was entirely comprised of 69 UCLA affiliated students and staff. Many studies did not report race (Allen, 1996; Charette et al., 1990; Christensen et al., 1989; Mello et al., 1990; Pomerleau et al., 1994), and the most diverse samples contained 73% Caucasian participants (Svikis et al., 2006). Social constructs of the menstruating woman vary by culture, and diverse samples may help tease out some of the social and hormonal contributors to alcohol use by cycle phase. Thus, future studies should aim to encompass more participants drawing from more diverse populations.

While there are some limitations in the studies reported here, there are many strengths. With such a dearth of information out there on alcohol consumption across the menstrual cycle phases, each of these studies contributes an important piece of information towards a goal of understanding alcohol use in women. Many of these studies are conducted prospectively, use daily diary, and follow women for many cycles (e.g., Tate & Charette, 1990).

Conclusions

Based on the present review of the existing research on alcohol consumption by menstrual cycle over more than 40 years, the primary conclusion to be drawn may be that the vast majority of this research suffers from significant limitations. The findings are varied, with the majority of studies finding either increased premenstrual alcohol consumption or no change in alcohol consumption by cycle. Methodological rigor in

these studies is weak, with methods varying across the 13 studies reviewed here in cycle phase determination and measures of alcohol consumption. Recommendations for future research include more rigorous practices surrounding cycle phase determination and alcohol consumption measures and utilizing diverse samples with sufficient participants for appropriate statistical power.

Research on menstrual cycle can be effectively conducted by following these recommendations. First of all, research should control for hormonal contraceptive use to ensure the hormonal profile is that of freely cycling women. Controlling for hormone use by utilizing freely cycling women as participants increases the likelihood that the hormonal profile follows the expected patterns. Secondly, menstrual cycle determination should use clear and standardized definitions of menstrual cycle phase. At a minimum, researchers should control for cycle phase of test administration, and acknowledge the hormonal profile targeted in the menstrual cycle phase. For example, providing a rationale for the window used in assessing the premenstrual week to measure falling progesterone. In a more ideal design, research should utilize repeated measures design to discern within women between the follicular and luteal phases of the cycle. Optimal measurement of the follicular phase and luteal phase would occur during the mid follicular phase or days 5-9 following the first day of menstrual bleeding when progesterone and estrogen are steady and in the luteal phase in days 8-12 following confirmed ovulation when progesterone and estrogen are dropping. For a more nuanced perspective of cycle phases, the task force on menstrual cycle research delineates cycle phases for research in women (Sommer, 1986). Additionally, research should confirm ovulation in women to ensure the latter part of the menstrual cycle has the hormonal

profile expected. Ovulation confirmation can be easily obtained with luteinizing hormone pee sticks, or more thoroughly with basal body temperature.

Research on alcohol use in women would be much improved by using validated standardized drinking measure (e.g., standard ethanol content) to assess alcohol consumption accurately. For instance, the Timeline Follow Back (Sobell et al., 1996) is a calendar assessment where participants are guided through a calendar period to assess each day for alcohol and other drug use. Alcohol consumption is then calculated based on standard ethanol content of beverages consumed. The Timeline Follow Back has been found to be a reliable measure of alcohol consumption by recall. If these recommendations are addressed future studies may help address a major women's health and public health concern by elucidating if menstrual cycle is one part of the determinates of alcohol consumption in young adult women.

3. Dissertation Project: The influence of menstrual cycle on dispositional factors that predict alcohol consumption in young adult women

This project was supported by funding from NIAAA 5F31AA023126-03 awarded to Haley Carroll

Abstract

Alcohol use is a significant contributor to global burden of disease (H. A. Whiteford et al., 2013), and even with evidence that the epidemiological gap in alcohol consumption between men and women is closing (Slade et al., 2016), there is a dearth of information in the mechanisms of alcohol consumption in women (IOM, 2010). Given the relationship between menstrual cycle phase and stress reactivity (M. Kathleen B. Lustyk et al., 2010), a common precipitant of alcohol consumption, the present study investigated the relationship between menstrual cycle phase and alcohol consumption, impulsivity (Delay Discounting, UPPSP), and Cardiac Vagal Control (CVC); and the moderation of these relationships by attention control (Mindfulness, Decentering, Rumination) in freely cycling young adult women (N = 59) within a neurobehavioral regulatory model. Results revealed no significant impact of menstrual cycle phase on alcohol consumption and CVC, and only moderate influence on impulsivity (sensation seeking only). There were both positive and negative relationships between mindfulness and impulsivity and CVC, with several significant interactions with menstrual cycle phase. Overall, these results suggest that menstrual cycle has little influence on alcohol consumption in women, and supports other research that suggests different mindfulness factors have unique relationships with impulsivity factors.

Keywords: Alcohol consumption, Menstrual Cycle, Impulsivity, Mindfulness, Cardiac Vagal Control

Introduction

Alcohol consumption and alcohol use disorders are a significant public health burden. In particular, alcohol consumption is one of the largest contributors to the global burden of disease, accounting for 10% of disability-adjusted life years (Whiteford et al., 2013). While alcohol use and alcohol use disorders have historically been higher in men, more recent evidence suggests that the sex gap is closing (Brady & Randall, 1999; Keyes, Martins, Blanco, & Hasin, 2010; Slade et al., 2016). Alcohol consumption in women is less well understood, given a dearth of research on women and alcohol use (Institute of Medicine (IOM), 2010b; SAMHSA, 2011). Moreover, women are at a greater risk for health related consequences due to moderate alcohol use (e.g., liver or heart disease) than men (National Institute on Alcohol Abuse and Alcoholism, (NIAAA), 2011). Given the chronic and progressive nature of alcohol-induced health consequences, understanding pathways to disease states from inception or outset is imperative. In particular alcohol use is highest in young adult cohorts (Grant et al., 2015), and understanding alcohol consumption in young adult women is an important public health concern. The present study applies a model of neurobehavioral regulatory systems to assess alcohol consumption in young adult women.

1.1 Cycle Phase and Alcohol

Stress and negative life events often precede problematic alcohol consumption. Among women especially, negative emotions commonly precipitate problematic drinking (Otto, Powers, & Fischmann, 2005). Many individuals with alcohol use disorders are drawn to alcohol as a means of emotional coping given its temporary, stress dampening effects (Hefner & Curtin, 2012). Alcohol use disorder risk increases when individuals

consistently resort to alcohol consumption instead of more effective coping strategies. Among young adults, drinking to cope is an important predictor of alcohol use (Harrell & Karim, 2008). In young women in particular, stressful life events contribute to prediction of a heavy drinking trajectory (Windle, Mun, & Windle, 2005). Thus, understanding the link between stress vulnerability and alcohol use among young women is an important research priority.

Young women represent an ideal subgroup of individuals to address the need for greater information regarding the etiological patterns of alcohol use in women. In particular, healthy, reproductively viable, cis-gendered and freely-cycling women (hereafter referred to as freely-cycling women) present an opportunity each month to study naturally occurring variability in stress vulnerability within their menstrual cycle. Research has consistently shown increased stress reactivity in the luteal phase of freely-cycling women as compared to the mid-follicular phase (Lustyk, Olson, Gerrish, Holder, & Widman, 2010). To date, existing research on menstrual cycle and alcohol consumption yields mixed results (Carroll, Lustyk, & Larimer, 2015).

A systematic review of existing studies suggests that methodology for measuring menstrual cycle phase may influence results (Carroll, Lusyk, & Larimer, 2015). With a healthy, endogenous menstrual cycle, the follicular phase, or the first half of the menstrual phase, before the time window associated with ovulation, is characterized by steady levels of progesterone and estrogen. Whereas in the luteal phase, the phase following ovulation and associated with the formation of the corpus luteum within the ovary, progesterone levels follow a curvilinear pattern. The luteal phase is fairly consistent in its length, typically about 12 +/- 2 days long. As such, variation between

and within woman in menstrual cycle length results from variations in follicular phase length. The varying length of the follicular phase and day of initiation of the luteal phase may result in some researchers conducting laboratory tests when hormone levels are varied. For example, a more restricted luteal window such as days 5-9 following ovulation is more likely to capture women during the peak estrogen and progesterone levels, whereas a longer luteal phase window such as days 6-13 following ovulation will likely capture women when estrogen and progesterone levels are rapidly falling leading up to menstruation. Indeed, what window researchers use for estimating cycle phase influences whether or not they find increases or no change in alcohol consumption in women (Carroll, Lustyk, & Larimer, 2015). Thus, the present study utilizes optimal measurement of alcohol use quantity and frequency and cycle phase timing to elucidate any difference in alcohol consumption by cycle phase. Optimal measurement of the follicular phase and luteal phase, as utilized in the present study, would occur during the mid-follicular phase (days 5-9 following the first day of bleeding) when progesterone and estrogen are steady and in the luteal phase in days 8-12 following confirmed ovulation when progesterone and estrogen are dropping but menses has not yet started and stress is highest.

One way to account for the inter-relationship of cycle phase, alcohol consumption, and drinking to cope is to view them within the context of neurobehavioral regulatory systems while considering dispositional factors associated with problematic drinking. All humans are confronted with decisions in their daily lives that require assigning value to possible rewarding and punishing stimuli, making predictions about when and where they will encounter these stimuli, and taking behavioral actions

informed by these predictions (O'Doherty, 2004). Often, these daily decisions require choosing between lower effort or immediately available, but less rewarding options versus higher effort or more delayed, but more rewarding options.

Optimal decision making requires the balance and coordination of two separate regulatory systems: an impulsive system, involved primarily in the valuation of immediate rewards and an executive system, involved primarily in considering and selecting rewards available in the future (e.g., Bechara, 2005). Even at times of low stress, when there is presumably optimal tuning of these two regulatory systems, considerable evidence indicates that humans tend to show a preference for the immediate, smaller rewards (Bickel et al., 2012). However, when stress is high, these regulatory systems can fall into a state of imbalance wherein engagement of the executive function to dampen impulsive proclivity becomes an even more strenuous task (e.g., Lempert, Porcelli, Delgado, & Tricomi, 2012). In particular, delay-discounting, a measure requiring participants to make a choice between immediate, smaller and delayed, larger monetary rewards, relates to alcohol use variables in young adults (Bobova et al., 2009; Kollins, 2003).

1.2 Impulsivity and Alcohol Use

High levels of impulsivity is a strong predictor of alcohol use as a coping mechanism and even stronger in relation to alcohol use disorders (Magid, MacLean & Colder, 2007). Moreover, increasing alcohol consumption and dependence modifies the body's homeostasis, reducing the body's self-regulation techniques and exacerbating impulsive behaviors (Dick, Smith, Olausson, Mitchell, Leeman et al., 2010). Often characterized by the inability to plan, delay gratification, poor inhibition, and lack of

executive function, impulsivity is a multifaceted construct. (Stoltnberg, Batien & Birgengeir, 2008; Murphy & MacKillop, 2012). Furthermore, when broken apart into five domains: 1) positive urgency, 2) negative urgency, 3) lack of planning, 4) lack of perseverance and 5) sensation seeking, impulsivity demonstrates both behavioral and dispositional traits (Magid et al., 2007).

Therefore, both behavioral and dispositional measures must be accounted for when measuring for impulsivity. When assessing for dispositional impulsivity, questionnaires such as the UPPS-P measure the breadth of the impulsivity construct by assessing four domains of impulsivity: urgency, premeditation (lack of), perseverance (lack of), and sensation seeking (Magid & Colder, 2007; Whiteside & Lynam, 2000). Urgency, subdivided into positive and negative groups, refers to engaging in impulsive behavior to bolster positive experiences or alleviate negative emotional distress. Premeditation (lack of) relates to acting without reflecting on the consequences, whereas, perseverance (lack of) pertains to maintaining attention to a difficult or boring task regardless of fatigue. Sensation seeking reflects the preference for novel and exciting behaviors regardless of the risk (Cyders, Smith, Spillane, Fischer, Annus, & Peterson, 2007; Whiteside, 2000). From a behavioral standpoint, delay discounting, a measure of risk-sensitivity, provides information on an individual's impulsive tendencies by assessing participants who choose between smaller rewards now or larger rewards later (Murphy et al., 2012). Because decision-making is a function of two regulatory systems, impulsive and executive function, participants who favor the immediate, smaller reward demonstrate impulsive tendencies (Dick et al., 2010).Given that risk factors in general are significantly correlated to increase substance abuse, impulsivity is a significant risk factor

on alcohol use and development of alcohol use disorders (Hawkins, Catalano & Miller, 1992).

Currently, the breadth of research on risk factors between sex and alcohol use is inconsistent. This may be explained by wide variety of factors examined, such as societal expectations, physical differences, or cultural differences (Brady & Randall, 1999; Nolen-Hoeksema, 2004; Hawkins et al., 1992). Although many variables contributing to alcohol use may differ between men and women, Wilsnack, Vogeltanz, Wilsnack and Harris (2000) reported that additional focus on biological differences is warranted. Indeed, one biological factor that may differentiate alcohol use in women is menstrual cycle phase. In particular, the luteal phase is associated with higher levels of stress reactivity (Lustyk et al., 2010), which may potentially serve as a trigger for impulsive decisions. Thus, the present study looks at the relationship between menstrual cycle phase and impulsivity.

1.3 Cardiac Vagal Control and Alcohol Use

Executive control is a complex cognitive system. It is comprised of several different sub-systems including attention control, cognitive flexibility, inhibitory control, working memory, and higher level cognitive skills such as reasoning. With respect to the cognitive flexibility, one important biobehavioral index is cardiac vagal control (CVC; e.g., high-frequency heart rate variability; e.g., Porges, 1995). CVC is a measure of time variance between adjacent R waves (indicative of ventricular depolarization) on the electrocardiogram. Spectral analysis of R-R variance, or the variance between subsequent R wave peaks, allows for the inspection of power density as a function of frequency, yielding high-, low-, and very low- frequency power densities. In particular, high

frequency power density is the measure of vagal traffic to the sinoatrial node, or what some call vagal braking. Higher tonic (i.e., baseline) CVC, viewed as a marker of superior self-regulation and adaptability to stress, is increasingly seen as a possible peripheral physiological marker of effective and flexible cortical control associated with adaptive emotion regulation (Thayer, Ahs, Fredrikson, Sollers, & Wagner, 2012). With respect to alcohol use, low tonic CVC is associated with a history of alcoholism (Ingjaldsson et al., 2003). Data on the stability of CVC across the menstrual cycle is somewhat mixed with some studies suggesting no significant difference in R-R variability by cycle phase (Cooke et al., 2002) and others revealing differences in R-R variability such that the luteal phase is associated with lower CVC (Tanaka et al., 2003). Thus, this study investigates the relationship between CVC and menstrual cycle phase and CVC and alcohol use.

1.4 Attention Control Moderator of risk factors

In regards to the attention control system, recent research indicates that mindfulness, or the ability to pay attention to the present moment in a non-judgmental manner, is associated with reduced alcohol use (e.g., Fernandez, Wood, Stein, & Rossi, 2010) and impulsive behaviors (Margolin et al., 2006), and increased CVC (e.g., Brewer et al., 2009). Bishop and colleagues (2004) have articulated a two-component description of mindfulness. The first component is described as self-regulation of attention focused on the immediate present experience. Self-regulation of attention involves paying attention to the present experience in a non-elaborative manner, or the ability to focus on present moment experiences without being "carried away" by elaboration or stories about the present moment. The second component of mindfulness is orientation towards the

present moment in a very particular way that involves an attitude of curiosity and openness, while accepting present moment experience as simply what is – in the moment (Bishop et al., 2004). Considerable evidence demonstrates the benefits of mindfulness meditation for physical (Ospina et al., 2008) and psychiatric conditions (Hofmann, Grossman, & Hinton, 2011) including substance use (Zgierska et al., 2009). Relatedly, decentering is defined as a metacognitive capacity to observe items that arise in the mind (e.g., thoughts, feelings, memories) with healthy psychological distance, greater self-awareness and perspective taking (Fresco et al., 2007). A series of studies have validated decentering as a construct important in acute and enduring treatment of major depressive disorder (MDD; (Fresco et al., 2007) and prevention of MDD relapse following prophylactic treatment with mindfulness based cognitive therapy (Bieling et al., 2012).

Mindfulness also relates to executive system measures in individuals receiving treatment for substance use disorders. Studies have investigated CVC to stress provocation in substance use disorders as an index of post-treatment self-regulatory capabilities. For example, Brewer and colleagues (Brewer et al., 2009) compared CVC in participants receiving treatment for alcohol or cocaine dependence with either 12-weeks of cognitive-behavioral therapy (CBT) or 9-weeks of mindfulness-training therapy; a technique adapted from mindfulness based relapse prevention as developed by Bowen and colleagues (Bowen, Chawla, Marlatt, & Parks, 2010). Participants provided details on a stressful event, which was read back to them during a laboratory session while physiology was monitored. The mindfulness-training group showed increased CVC during stress provocation as compared to the CBT group, who showed a significant increase in sympathetic activity. Similarly, participants with alcohol dependence who

completed a mindfulness oriented recovery enhancement (MORE) group as compared to an alcohol support group evidenced higher CVC during the alcohol cue-stressor with decreased CVC post-stressor (Garland et al., 2010). Thus, mindfulness is a deployable skill linked to higher CVC in the face of stress. Given that the luteal phase is associated with increased stress reactivity, dispositional mindfulness may prepare individuals to better adapt to luteal phase changes via higher CVC.

Additionally, higher levels of stress (Galván & McGlennen, 2012) and emotional distress (Tice, Bratslavsky, & Baumeister, 2001) have been linked to greater preference for immediate rewards. Dispositional mindfulness has been shown to mitigate neuroaffective reactions to positive performance feedback (Teper & Inzlicht, 2014), and thus, may be associated with lower delay discounting. Further, neural evidence suggests that higher dispositional mindfulness is negatively correlated with grey matter volume in subcortical areas associated with stress reactivity (r. amygdala) and reward processing (l. caudate; Taren, Creswell, & Gianaros, 2013). Thus, during times of depleted self-control resources, like the luteal phase, high trait mindfulness may buffer the effects of stress by helping to maintain top-down control and mitigating the impulse for immediate bottom-up reward. As such, the current study looks at mindfulness as a moderator between cycle phase and alcohol consumption, and between cycle phase and alcohol consumption risk factors.

1.5 Study Purpose

The purpose of the present study is to investigate menstrual cycle phase on alcohol consumption and alcohol consumption risk factors. The first aim is to investigate the main effects of menstrual cycle phase on alcohol use, impulsivity, and CVC. We

hypothesize that alcohol use and impulsivity will be greater during the late luteal phase compared to the mid-follicular phase. Given that evidence is mixed on the relationship between menstrual cycle phase and cognitive flexibility, or CVC, we do not have an a priori hypothesis. The second aim is to examine the moderating effect of attention control on the relationships between menstrual cycle phase and impulsivity, menstrual cycle phase and CVC, and menstrual cycle phase and alcohol consumption. We predict that attention control, or mindfulness, will moderate the relationship between cycle phase and impulsivity, cycle phase and CVC, and cycle phase and alcohol use, such that those with higher attention control will have lower alcohol consumption and lower risk factors for alcohol use.

2. Methods

2.1 Recruitment

Women were recruited from the local area via fliers and online advertisements (e.g., craigslist and campus list serves), and instructed to call for telephone screening. Telephone screening assessed for eligibility.

Inclusion criteria for this study were:

1. Being a post-menarcheal female in at least her 6th gynecological year and premenopausal in the peak drinking young adult 18-49 age range. The age range criteria was chosen to access women with both regular menstrual cyclicity, who are also within the adult age ranges most affected by alcohol use (e.g., Grant et al., 2008). According to the current guidelines of the American Academy of Pediatrics, Committee on Adolescence, American College of Obstetricians and Gynecologists and Committee on Adolescent Health Care (Diaz et al., 2006), it takes 6 years post-menarche for the

majority of girls to establish regular menstrual cycles with ovulation. Given the average age of menarche is 13, we did not recruit women under the age of 18.

2. Being freely cycling (i.e., no cycle suppression via hormones or absence through surgery) with menstrual cycles between 21-35 days with regular menstrual cyclicity. These inclusion criteria were developmentally appropriate as women between the ages of 20 and 40 have the least variability in their cycle length with the fewest annovulatory cycles (Mishell, 2001).

3. Being able to read and speak English in order to complete the assessments provided in English.

4. Willingness to come to the Lab on two occasions (Follicular and Luteal) to perform the laboratory testing procedure.

Exclusion criteria for this study were:

1. Taking medication that affects the heart (e.g., beta blockers) or lungs (e.g., asthma and allergy meds). This exclusion was necessary to prevent the CVC measures, which rely on heart and respiration rate, from being skewed.

2. Having current psychosis, suicidal ideation, or present major depressive or anxiety disorder, or a history of treatment for such disorder within the past 6-months as assessed by the *Mini International Neuropsychiatric Interview* (M.I.N.I.; Sheehan et al., 1998). However, given that alcohol use is of interest in the present analyses, individuals were not excluded on the basis of an alcohol use disorder.

3. Having experienced a traumatic life event in the past 6-months (assessed by the M.I.N.I.). Given that life stressors can alter CVC, it was important to control for recent trauma history.

4. Being pregnant or nursing within the past 6-months. Regular cyclicity is part of the eligibility criteria, and pregnancy and nursing alter the menstrual cycle.

2.2 Procedures

Women were scheduled for two laboratory assessments. In return for participation, women were reimbursed via university credit or gift-card reimbursement of $50 ($10 first lab session and $40 second lab session). Participants were randomly assigned to follicular or luteal start date. Counting the first day of menses as day 1 of the participant's cycle, we scheduled the follicular testing session during days 5-9 and luteal testing days 8-12 post-ovulation. One limitation due to the nature of cycle phase testing is the researcher cannot be blind to condition. The researcher must confirm ovulation with the participant and know the appropriate window to schedule the participant, which renders blind testing infeasible. To address this limitation research protocols and scripts were standardized, with as many computerized protocols as possible (e.g., blood pressure, impulsivity task).

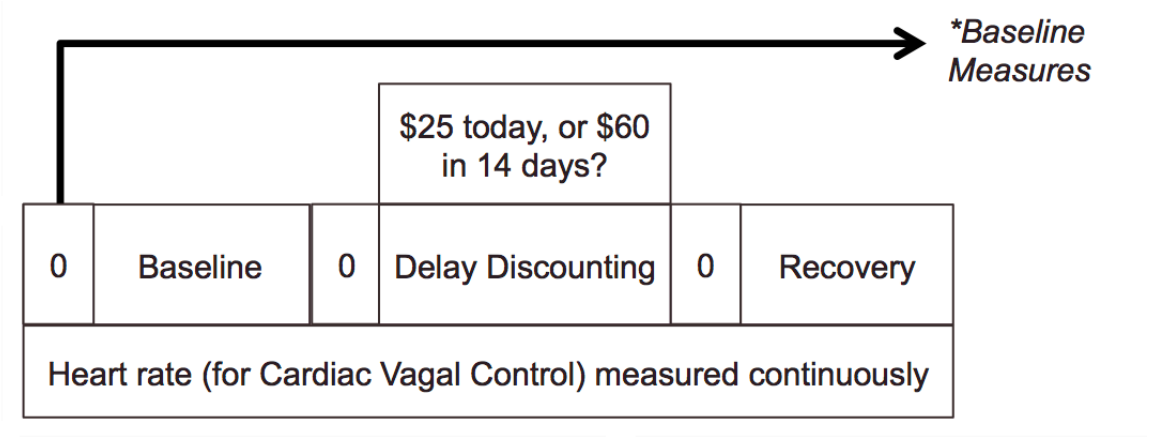
Luteal Start: Participants randomized to the luteal start group were invited to the lab to sign the informed consent form and receive ovulation test sticks. A trained Research Assistant (RA) demonstrated proper use of the test stick and instructed them to call the lab when they test positive for ovulation, so as to schedule their luteal test session during days 8-12 post-ovulation.

Follicular Start: Participants randomized to the follicular start group called the lab on their first day of bleeding during menstruation to schedule the follicular test session 5-9 days post-menses onset. Follicular start participants provided written consent at the initial assessment. Following the assessment, the RA provided the participant with

ovulation test sticks, detailed instructions for use, and instructions to call to schedule the luteal test 8-12 days post-ovulation.

Laboratory Testing Sessions. Figure 3 outlines procedures for laboratory testing. The day prior to the lab session, participants were reminded by email or phone to abstain from substances known to affect stress testing. In particular participants were asked to avoid alcohol within 12 hours; over the counter medications like antihistamines, decongestants, vitamin/herbal supplements, pain medication that affect CVC on the morning of testing; and vigorous exercise and caffeine, food or drink other than water within 1 hour of the session. When the participant arrived for testing verbal confirmation of adherence to these restrictions was obtained. No restrictions were violated, and all participants completed assessments as scheduled. Following consent, participants were seated in a semi reclined chair (outpatient surgery recovery style), and began paper and pencil measures described in Table 1. After the participant was prepped for psychophysiological measurement, they rested for a 10-min baseline, completed the computerized impulsivity task, and rested for a 10-min recovery period.

Figure 3. Laboratory Testing Procedures



2.3 Measures

Paper and Pencil Measures

Paper and pencil measures were all completed at the beginning of each laboratory session. Table 1 identifies which measures were administrated at lab session 1 and lab session 2.

Table 1. Measure Administration Across Laboratory Sessions

	Variable	***Assessment***	***Reference***	***L***	***F***
Baseline	*Demographic*	*Age, ethnicity, etc.*		*Visit 1*	
Cardiac Vagal Control	*Cardiac Vagal Control*	*Spectral Analysis*	*Task Force, 1996*	*x*	*x*
Impulsive	*Delay Discounting*	*Computer Assessment*	*Kirby et al., 1999*	*x*	*x*

	Impulsivity	*UPPS-P*	*Cyders et al., 2007*	*x*	*x*
Attention Control	*Trait Mindfulness*	*Five Factor Mindfulness*	*Bayer et al., 2006*		*x*
		CAMSR	*Feldman et al., 2007*		*x*
		MAAS	*Brown et al., 2003*		*x*
	Decentering	*Experiences Questionnaire*	*Fresco et al., 2007*		*x*

Demographics

Variables such as participant sex, age, and ethnicity were all assessed at baseline via a paper and pencil measure.

Cardiac Vagal Control

CVC was measured via high-frequency heart rate variability. Pre-processing methods was conducted in accordance with the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology guidelines (Bernston et al., 1997) and are described in more detail in the data analysis section.

Impulsive Systems

Delay Discounting

Delay discounting was assessed via a computerized version of the Monetary-Choice Questionnaire developed by Kirby and colleagues (Kirby, Petry, & Bickel, 1999).

In this computerized impulsivity assessment (CIA), participants are presented with two hypothetical amounts of money that are associated with a specific delay; one amount is immediately available, and the other amount is delayed. With each pair, participants are required to choose either of the two amounts of money. The results from the task are converted into a hyperbolic parameter (k) function (described in data processing) score as described by the progenitor of the task (Kirkby, 2000). The k score determined to estimate the point at which participants switch from a preference for a more immediate and smaller reward to a more delayed and larger reward. A higher k score is associated with more preference for the more immediate reward.

The computerized impulsivity assessment was given at both luteal and follicular lab sessions and took approximately 5 min to complete. The task was run via E-Prime in accordance with task design outlined by Kirkby and colleagues (1999).

Impulsivity

Trait impulsivity was assessed via the 59-item UPPS-P measure (Lyman, Smith, Whiteside, & Cyders, 2006), which measures impulsivity across the Five Factor Model of personality. The UPPS-P includes subscales of negative urgency (i.e. “When I feel rejected, I will often say things that I later regret”), lack of perseverance (i.e. “Sometimes there are so many little things to be done that I just ignore them all”), lack of premeditation (i.e. “Before making up my mind, I consider all the advantages and disadvantages”), sensation seeking (i.e. “I would enjoy water skiing”), and positive urgency (i.e. “I am surprised at the things I do while in a great mood”). Typically, each item is rated on a 4-point scale where 1 = agree strongly and 4 = disagree strongly, where 1 reflects the participant does not endorse impulsive behaviors and 4 reflects high levels

of impulsivity. However, due to an error, the UPPSP was administered with response items on a 5-point Likert-scale, where 1= not at all to 5= very much. From there, questions were differentiated by subscales, then mean scores were calculated to determine self-reported levels of impulsivity. Various items from each subscale were reverse coded, before the means of the total score as well as the subscale scores were calculated, such that lower scores indicated higher levels of impulsive behavior. As such, we refer to the scales in a way that is more intuitive to their interpretation. Higher scores indicate lack of negative urgency, a lack of sensation seeking, a lack of positive urgency, or higher premeditation, and perseverance.

Executive Control: Attention Control

Mindfulness

Mindfulness was assessed via four paper and pencil measures. Trait mindfulness was measured by the Five-Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006), which consists of five first order factors with demonstrated internal-consistency called: 1) observing, 2) describing, 3) acting with awareness, 4) non-judging, and 5) non-reactivity. The FFMQ is 39-items where participants rate questions such as "I'm good at finding words to describing my feelings" on a 5-point scale ranging from 1 = never or rarely true to 5 = very often or always true.

Additionally, the Cognitive and Affective Mindfulness Scale-Revised (CAMS-R; Feldman et al., 2007) assessed individual differences in mindfulness approaches throughout day-to-day experiences and shows internal consistency across four constructs of mindfulness: 1) attention, 2) present-focus, 3) awareness, 4) acceptance. The CAMS-R is 12-items where participants to rate how frequent questions, such as "It's easy for me to

concentrate on what I am doing" occur on a 4-point Likert scale ranging from 1=rarely or not at all to 4 = almost always.

The Mindful Attention Awareness Scale (MAAS; Brown et al., 2003) measured dispositional mindfulness, defined as receptive awareness of and attention to what is taking place in the present. The scale, also predictive of self-regulation and well-being constructs, demonstrates excellent internal consistency. The MAAS consists of 15-items where participants rate how frequent questions, such as "I could be experiencing some emotion and not be conscious of it until sometime later" and "I snack without being aware that I am eating" occur on a 6-point scale where 1 = almost always and 6 = almost never.

Decentering, or the meta-cognitive ability to relate to thoughts and feelings that arise in a healthy manner (e.g., thoughts are not facts), and rumination, or the preoccupation and attachment with your thoughts (e.g., thinking too much about your thinking) was assessed by the Experiences Questionnaire (EQ; Fresco et al., 2007). The EQ consists of 20-items where participants rate how often they experience statements like "I can separate myself from my thoughts and feelings" on a 5-point scale where 1 = never and 5 = all the time. The EQ has two subscales, decentering (e.g., I can slow my thinking at times of stress) and rumination (e.g., I think about what will happen to me in my future).

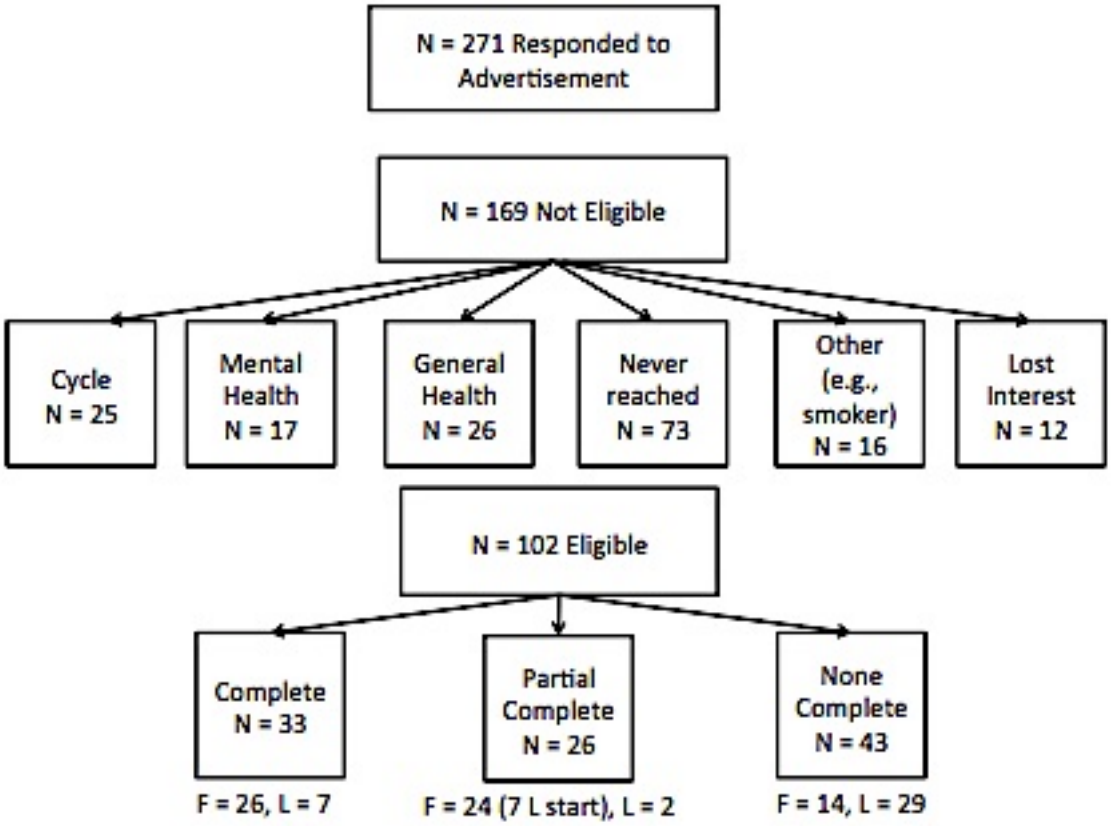
3. Results

3.1 Participants

Women who responded to the advertisements (n = 271) were screened via telephone for eligibility. Figure 1 graphically depicts the eligibility of participants. Of the

n = 271 women screened, *n* = 102 women were eligible and enrolled in the study. Of the *n* = 102 women that were eligible, *n* = 33 (32%) completed all assessments, *n* = 26 (26%) completed only one assessment, with a total of *n* = 59 (58%) completing at least one assessment.

Figure 4. Consort Diagram



While randomization was successful with *n* = 57 (56%) women assigned to start in the Follicular phase and *n* = 45 (44%) women assigned to start in the Luteal Phase, there was an imbalance in who completed assessments. More women completed all assessments (*n* = 26, 45%), one assessment (*n* = 17, 30%), or at least one assessment (*n* = 42, 75%) after being assigned to the Follicular Phase, than women that were assigned to the Luteal Phase and completed all assessments (*n* = 7, 16%), one assessment (*n* = 9, 20%), or at least one assessment (*n* = 16, 45%). This was likely due to a design flaw in

which participants experienced extra burden when randomly assigned to the Luteal condition. If assigned to the Luteal Phase, women were asked to come into the laboratory before their first assessment to collect LH test strips to confirm ovulation. In addition, these participants were asked to confirm ovulation. Not including time to get to the laboratory the ovulation meeting (10-15 min) and ovulation testing (with 4 min/day, 1-8 times, 4-28 min) could add up to an additional 14-43min burden. We believe this burden is responsible for the relatively high (64%) Luteal incompletion rate compared to those assigned to the Follicular phase (25%). As a result of this design flaw we ended up with full data for within women cycle comparisons in *n* = 33 women, with data for between women cross-section cycle comparison for *n* = 52 Follicular assessments and n = 40 Luteal assessments.

Table 2. Completion of Assessments by Randomization to Follicular or Luteal Phase Start

	Follicular Condition		**Luteal Condition**	
	N = 57		*N* = 45	
	Freq	%	Freq	%
All Assessment	26	45	7	16
Follicular Assessment	17	30	7	16
Luteal Assessment	0	0	2	4
No Assessment	14	25	29	64

3.2 Demographics

Participants were 18 to 46 years old, with the average age of women being 23 years old (*SD* = 6 years). In regards to race ethnicity the sample was fairly representative of Seattle demographics. Based on census data, we had a targeted enrollment of 16% Asian/Pacific Islander, 10% Black/African American, 2% Native American/Alaskan, and 69% White/Caucasian American with 10% Hispanic/Mexican American. We enrolled 23% Asian/Pacific Islander, 12% Black/African American, 1% Native American/Alaskan, 56% White/Caucasian American, with 4% Hispanic/Mexican American and 2% Other. Thus, we met targeted enrollment percentages for all groups except Hispanic/Mexican American.

3.3 Data Reduction and Cleaning

Psychophysiological data were preprocessed (e.g., filter, invert, derivative) to maximize recognition of R-wave in calculations. Ectopic beats were removed with the program QRSTool (Allen, Chambers, & Towers, 2007). Then, using CMetx (Allen et al., 2007) RR interval power spectra was computed over equal 5-min recording intervals for baseline (0-5 min, 5-10 min), the delay discounting task (5 min), and recovery (0-5 min, 5-10 min). Fast Fourier transformations (FFT) were conducted on preprocessed data: FFT size = 1027. From CMetX, the frequency-domain metric of Respiratory Sinus Arrhythmia (RSA) were extracted for each 5-min time period for analysis in R. HRV is the natural log of the variance of the inter-beat-interval (IBI) time and is influenced by both the parasympathetic and sympathetic nervous system. Whereas RSA is considered a putative parasympathetic nervous system measure and is the natural log of the band limited (0.12 - 0.40 Hz) variance of the IBI time series. Thus, RSA is analogous to the high-frequency band of HRV.

Using reported alcohol consumption data from the TLFB, standard ethanol content for each reported day of drinking was determined by the calculator provided by the University of New Mexico's Center on Alcoholism, Substance Abuse, and Addictions (http://casaa.unm.edu/dload.html) to assess quantity of alcohol use. The standard ethanol content (SEC) calculator considers type of alchol consumed, and amount of alcohol consumed. A small percentage, $n = 16$ (27%), of participants drank at all in the study. Of the 16 participants that reported drinking, 14 reported drinking in the Follicular phase ($M = 0.38$ reported drinking days, and $M = 0.94$ SECs consumed) and 9 reported drinking in the Luteal Phase ($M = 0.27$ reported drinking days, and $M = 0.53$ SECs consumed). Given the low amount of alcohol consumption, a binary indicator of any alcohol use reported during each cycle phase assessment was created to assess alcohol consumption.

The impusivity task was scored using Kirby's guide for caluclating the hyperbolic discount paramenter (k) from the selections for more immediate or more delayed rewards made during the computerized impulsivity assessment (Kirby, 2000). The scoring method is described in detail in Kirby's guide (2000); however, I will describe the scoring methods in brief here. First, preference for larger more delayed rewards (LDR) over smaller more immediate rewards (SIR) during each trial is given a binary score. Next, the reward size of LDRs are differentiated into large, medium, and small categories to calculate estimated discounted rates within each reward size. These values are then sorted such that the large, medium, and small LDRs are in reward size order. Then, k, or the point at which the participant switches from a preference from the SIR to the LDR is calculated. From these values, the geometric mean was calculated to record each participant's k value. Thus, as described above, k represents the point at which

participants prefer the LDR to the SIR, and higher k values represent more preference for the SIR, or more impulsivity.

All variables were plotted and examined for distribution and outliers. Any significant outlier (3 *SD* above or below the *M*) was removed for analysis.

3.4 Data Analysis

In order to optimize the number of participants included in analyses, all analyses were run between subjects with all participants $N = 59$ (Follicular $n = 50$, Luteal $n = 28$). All data were analyzed with the statistical package R (Version 3.3.0).

First, bivariate analyses were used to check for covariation among the independent and dependent variables. No significant covariation was found. Additionally, independent samples t-tests were run to compare means for each covariate variable between those assigned to start in the Luteal and Follicular phase of the menstrual cycle. No significant group differences were found, suggesting that random assignment was successful even with the aforementioned complications. Descriptive Statistics on alcohol consumption, impulsivity, CVC, and attention control measures can all be found in Table 3.

Table 3. Descriptive Statistics of Outcome and Predictor Variables by Cycle Phase

	Follicular		**Luteal**	
	Count	**%**	**Count**	**%**
Alcohol				
Any Use	14	25	9	16
Impulsivity	**M**	**SD**	**M**	**SD**
Average k	0.025	0.026	0.024	0.038
Large k	0.006	0.004	0.011	0.023

Medium k	0.023	0.025	0.041	0.077
Small k	0.023	0.023	0.034	0.042
Negative Urgency	2.36	0.37	2.344	0.289
Lack Premeditation	2.72	0.35	2.697	0.361
Perseverance	2.83	0.37	2.78	0.377
Sensation Seeking	2.65	0.34	2.805	0.358
Positive Urgency	2.89	0.34	2.869	0.337
Cardiac Vagal Control	***M***	***SD***	***M***	***SD***
RSA				
Baseline 1-5	6.979	1.025	6.841	1.24
Baseline 5-10	6.945	1.019	6.806	1.156
CIA 1-5	6.809	1.000	6.756	1.097
Recovery 1-5	6.976	1.000	6.846	1.124
Recovery 5-10	6.853	1.053	6.755	0.965

	Baseline	
Attention Control	***M***	***SD***
MASS	4.180	0.819
CAMSR	34.785	4.891
FFMQ		
Act With Awareness	21.414	6.590
Describe	27.780	5.669
Observe	27.474	7.644
Non-judgment	22.103	6.630
Non-reaction	20.707	5.285
EQ		
Decenter	43.940	9.282
Rumination	21.319	3.535

Aim 1: Examine the main effect of cycle phase on impulsive and executive systems and alcohol use

Impulsive Systems

CIA

Paired sample t-tests were run to compare the luteal phase and follicular phase responses on the CIA. The differences between the luteal and follicular phases were not statistically significant for Average CIA (M = 0.003, t = 0.49, p = 0.63, CI = -0.008, 0.01), Large CIA (M = 0.01, t = 2.04, p = 0.05, CI = -0.0001, 0.02), Medium CIA responses (M = 0.005, t = 0.58, p = 0.57, CI = -0.01, 0.02), and Small CIA responses (M = 0.006, t = 1.79, p = 0.08, CI = -0.0009, 0.01).

Linear regressions were run to test if luteal phase predicted CIA impulsivity responses. Average (B = -0.003, p = 0.77, CI = -0.021, 0.016), Large (B = 0.005, p = 0.44, CI = -0.007, 0.016), Medium (B = -0.014, p = 0.40, CI = -0.05, 0.02) and Small (B = 0.001, p = 0.94, CI = -0.02, 0.24) CIA responses were all not significantly predicted by cycle phase.

UPPSP

Paired-samples t-tests were run to compare the luteal phase and follicular phase responses on the UPPSP. There was no significant cycle phase difference for negative urgency (M = -0.06, t = -1.06, p = 0.3, CI = -0.16, 0.05), premeditation (M = -0.02, t = -0.39, p = 0.7, CI = -0.13, 0.09), perseverance (M = -0.2, t = -0.26, p = 0.8, CI = -0.15, 0.12), and positive urgency (M = -0.07, t = -2.03, p = 0.05, CI = -1.39, -0.00008). However, for sensation seeking (M = 0.09, t = 2.11, p = 0.04, CI = 0.003, 0.18) differences between the luteal and follicular phase were significant. Linear regressions

were run to test if luteal phase predicted paper and pencil UPPSP impulsivity responses. The results for negative urgency (B = -0.009, p = 0.78, CI = -0.15, 0.12), premeditation (B = -0.014, p = 0.688, CI = -0.17, 0.12), perseverance (B = -0.021, p = 0.58, CI = -0.2, 0.1), and positive urgency (B = 0.0002, p = 0.996, CI = -0.16, 0.12) all suggest no significant relationship between cycle phase and impulsivity. However, for sensation seeking (B = 0.17, p = <0.001, CI = 0.01, 0.29) a positive and significant relationship between cycle phase and impulsivity emerged. Cohen's D revealed a small effect size (*Cohen's D* = 0.43). In combination, this suggests that sensation seeking is slightly higher in the luteal phase for young adult women.

Cardiac Vagal Control

RSA

Paired-samples t-tests were run to compare the luteal phase and follicular phase RSA during the laboratory testing. There were no significant cycle phase differences for RSA during the first 5 min of baseline (M = 0.008, t = 0.04, p = 0.97, CI = -0.41, 0.42), the second 5 min of baseline (M = 0.05, t = 0.28, p = 0.79, CI = -0.34, 0.44), during the CIA task (M = -0.211, t = -1.17, p = 0.25, CI = -0.58, 0.16), or during the first 5 min of recovery (M = -0.12, t = -0.64, p = 0.52, CI = -0.49, 0.26), nor the second 5 min of recovery (M = -0.08, t = -0.431, p = 0.67, CI = -0.46, 0.3).

Linear regressions were run to test if luteal phase predicted RSA responses during the laboratory testing. The results for the first 5 min of baseline (B = -0.159, p = 0.52, CI = -0.67, 0.35), the second 5 min of baseline (B = -0.155, p = 0.537, CI = -0.65, 0.34), during the CIA task (B = -0.084, p = 0.728, CI = -0.56, 0.4), or during the first 5 min of recovery (B = -0.177, p = 0.461, CI = -0.65, 0.29) and the second 5 min of recovery (B =

-0.133, $p = 0.575$, $CI = -0.6, 0.34$) all suggest no significant relationship between cycle phase and RSA.

Alcohol Use

Paired-samples t-tests were run to compare the luteal phase and follicular phase alcohol consumption. There was no significant difference between alcohol consumption in the follicular and luteal phase ($M = 0.11$, $t = 1.43$, $p = 0.16$, $CI = -0.04, 0.25$).

Logistic regression was run to test if luteal phase predicted alcohol consumption. The results suggest that there is no significant difference between luteal and follicular phase alcohol consumption ($B = -0.26$, $p = 0.58$, $CI = -1.24, 0.67$).

Aim 2: Examine the moderating affect of Attention Control on relationships between Cycle phase and the Impulsive Stystem, Cycle phase and Cardiac Vagal Control, and Cycle phase and Alcohol Use

Impulsive System

Computerized Impulsivity Assessment

Even with very few significant main effects, there is potential for cross-over interactions. Thus, multiple regressions were run with interactions to test if the relationship between menstrual cycle phase and CIA impulsivity is moderated by mindfulness. None of the relationships between menstrual cycle phase, CIA, and the MASS, the CAMSR, and all factors of the FMMQ were statistically significant. However, the relationship between cycle phase and CIA and the EQ revealed a few statistically significant relationships. In Table 4, you can see significant relationships between EQ decenter and Average CIA and EQ decenter and Small CIA. Additionally, the interactions for EQ rumination and Medium and Small CIA were significant. We

graphed the simple slopes of the significant interactions (Figure 3). The interactions suggest that higher rumination (+1 *SD* of EQ decenter) relates to a higher k score in the follicular phase, but for the luteal phase this relationship does not hold.

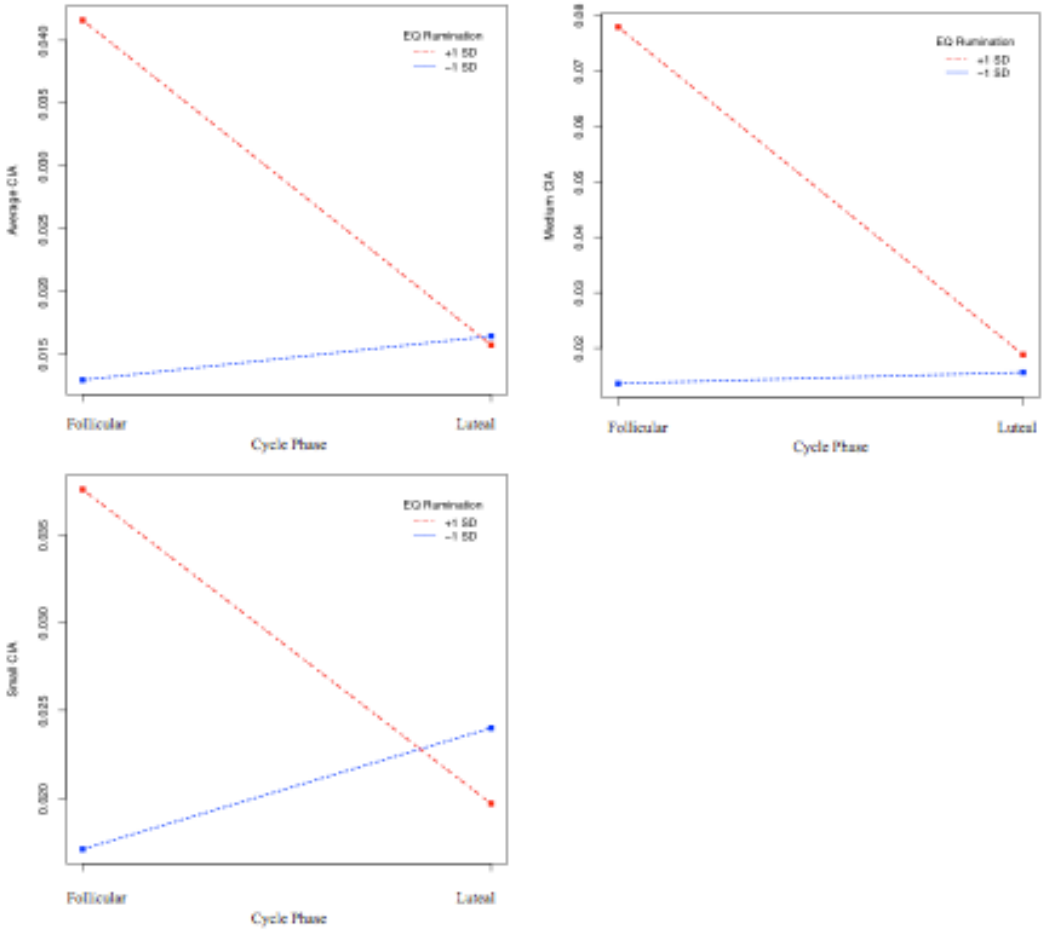
Table 4. Multiple regression coefficients assessing the moderation of the relationship between Menstrual Cycle Phase and CIA by mindfulness

	Average					Large					Medium					Small				
	B	SE	p	CI- 2.5%	97.5%	B	SE	p	CI- 2.5%	97.5%	B	SE	p	CI- 2.5%	97.5%	B	SE	p	CI- 2.5%	97.5%
Luteal	0.019	0.045	0.668	-0.071	0.110	0.002	0.029	0.955	-0.057	0.060	0.063	0.08	0.432	-0.097	0.224	-0.007	0.058	0.91	-0.123	0.110
MAAS	0.004	0.008	0.624	-0.012	0.012	< 0.001	0.005	0.931	-0.011	0.010	0.016	0.014	0.257	-0.012	0.044	-0.004	0.01	0.701	-0.024	0.016
Luteal * MAAS	-0.005	0.11	0.617	-0.027	0.016	0.001	0.007	0.919	-0.013	0.015	-0.019	0.019	0.33	-0.056	0.019	0.002	0.014	0.895	-0.026	0.029
Luteal	-0.008	0.026	0.75	-0.061	0.045	0.003	0.015	0.843	-0.027	0.033	0.64	0.064	0.664	-0.159	0.103	0.0003	0.35	0.994	-0.071	0.072
Act with Awareness	0.001	0.001	0.206	-0.001	0.003	0.007	< 0.001	0.142	0.000	0.002	0.002	0.002	0.612	-0.003	0.005	0.001	0.001	0.202	-0.001	0.004
Luteal * AWA	< -0.001	0.001	0.927	-0.002	0.002	0.000	0.001	0.837	-0.001	0.001	0.003	0.003	0.983	-0.006	0.006	-0.0002	0.002	0.875	-0.003	0.003
Luteal	-0.005	0.056	0.931	-0.119	0.109	-0.004	0.031	0.9	-0.067	0.059	-0.043	0.1344	0.75	-0.318	0.231	0.032	0.073	0.662	-0.118	0.182
Describe	0.001	0.001	0.501	-0.002	0.004	0.001	0.001	0.355	-0.001	0.002	-0.0004	0.003	0.896	-0.007	0.006	0.002	0.002	0.172	-0.001	0.006
Luteal * Describe	< -0.001	0.002	0.92	-0.004	0.004	0.000	0.001	0.896	-0.002	0.002	0.0006	0.005	0.902	-0.009	0.010	-0.001	0.002	0.611	-0.006	0.004
Luteal	-0.003	0.032	0.926	-0.068	0.062	-0.021	0.180	0.24	-0.058	0.015	0.026	0.076	0.732	-0.129	0.182	-0.014	0.043	0.746	-0.101	0.073
Observe	< -0.001	0.001	0.82	-0.002	0.001	< 0.001	< 0.001	0.427	-0.001	0.001	0.0008	0.002	0.669	-0.003	0.005	-0.01	0.001	0.349	-0.003	0.001
Luteal * Observe	< -0.001	0.001	0.815	-0.003	0.002	0.001	0.001	0.22	<-0.001	0.002	-0.002	0.003	0.476	-0.007	0.003	0.0003	0.001	0.817	-0.003	0.003
Luteal	-0.037	0.029	0.213	-0.097	0.022	-0.021	0.018	0.24	-0.058	0.015	-0.114	0.068	0.104	-0.252	0.025	-0.004	0.038	0.906	-0.082	0.073
Non-Judgement	< -0.001	0.001	0.686	-0.002	0.001	-0.003	< 0.001	0.427	-0.001	0.001	-0.003	0.002	0.134	-0.007	0.001	0.001	0.001	0.21	-0.001	0.004
Luteal * NJ	0.001	0.001	0.347	-0.001	0.004	0.001	0.001	0.22	0.000	0.002	0.004	0.003	0.188	-0.002	0.010	< -0.001	0.002	0.985	-0.003	0.003
Luteal	0.003	0.034	0.921	-0.066	0.072	-0.021	0.019	0.262	<-0.001	0.017	0.051	0.08	0.528	-0.113	0.215	-0.02	0.045	0.668	-0.112	0.073
Non-reaction	< -0.001	0.001	0.885	-0.002	0.002	-0.001	0.001	0.144	-0.002	< 0.001	0.002	0.003	0.477	-0.003	0.007	-0.001	0.001	0.333	-0.004	0.002
Luetal * NR	-0.001	0.002	0.676	-0.004	0.003	0.001	0.001	0.243	-0.001	0.003	-0.004	0.004	0.323	-0.011	0.004	0.0007	0.002	0.736	-0.004	0.005
Luteal	-0.032	0.03	0.284	-0.027	0.091	0.020	0.020	0.314	-0.018	0.057	0.061	0.053	0.254	-0.044	0.166	0.016	0.038	0.684	-0.060	0.091
CAMSR	< -0.001	0.006	0.949	-0.001	0.001	0.000	0.000	0.807	-0.001	0.001	0.0002	0.001	0.807	-0.002	0.002	-0.0005	0.0008	0.539	-0.002	0.001
Luteal * CAMSR	-0.009	0.008	0.235	-0.003	0.001	0.000	0.001	0.453	-0.001	0.001	-0.002	0.001	0.151	-0.005	0.001	-0.0004	0.001	0.69	-0.003	0.002
Luteal	-0.003	0.019	0.887	-0.040	0.035	-0.016	0.010	0.069	-0.041	0.002	-0.024	0.046	0.603	-0.115	0.067	0.036	0.024	0.146	-0.013	0.084

EQ Decenter	0.001	< 0.001	0.026*	< -0.001	0.001	0.000	0.000	0.939	< -0.001	< 0.001	0.0003	0.0007	0.701	-0.001	0.002	0.002	0.0004	0.00001*	0.001	0.002
Luteal * Eqd	< -0.001	< 0.001	0.697	-0.001	0.001	0.000	0.000	0.057	< -0.001	0.001	-0.00005	0.001	0.964	-0.002	0.002	-0.0009	0.0005	0.098	-0.002	0.000
Luteal	0.077	0.021	< 0.001*	0.037	0.118	0.007	0.013	0.57	-0.018	0.033	0.156	0.05	0.002*	0.057	0.255	0.069	0.0302	0.023*	0.010	0.129
EQ Rumination	0.004	0.001	< 0.001*	0.003	0.005	< 0.001	< 0.001	0.656	-0.001	0.001	0.009	0.002	< 0.00001*	0.006	0.012	0.003	0.0009	0.003*	0.001	0.005
Luteal * EQR	-0.004	0.001	< 0.001*	-0.006	-0.002	< 0.001	0.001	0.597	-0.002	0.001	-0.009	0.002	0.0004*	-0.013	-0.004	-0.004	0.001	0.02*	-0.006	-0.001

Note = Luteal = Cycle phase dummy code where Luteal = 1, MAAS = Mindful Attention Awareness Scale, AWA = Act with Awareness, CAMSR = Cognitive and Affective Mindfulness Scale Revised, EQd = Experiences Questionnaire Decenter, EQr = Experiences Questionnaire Rumination, Large = Computerized Impulsivity Assessment Large Reward, Medium = Computerized Impulsivity Assessment Medium Reward, Small = Computerized Impulsivity Assessment Small Reward

Figure 3. Interactions between Average, Medium, and Small CIA and EQ Rumination



UPPSP

Paper and Pencil impulsivity

Multiple regressions were run with interactions to test if the relationship between menstrual cycle phase and UPPSP impulsivity is moderated by mindfulness. In Table 5, you can see significant positive relationships between the UPPSP impulsivity subscale lack of negative urgency, and various measures of mindfulness including the MAAS, the FFMQ subscales acting with awareness, and describe, and the CAMSR. Additionally,

there is a significant interaction between negative urgency, cycle phase and EQ subscale decenter.

Next, there are significant negative relationships with between the UPPSP impulsivity subscale premeditation and various measures of mindfulness including the MAAS, the FFMQ subscale acting with awareness, and the CAMSR. Moreover, there is a significant interaction between the UPPSP impulsivity subscale premeditation, menstrual cycle phase and the EQ subscale decenter.

You can also see significant positive relationships with the UPPSP subscale lack of positive urgency and various measures of mindfulness including the MAAS, the FFMQ subscale of describe and non-reactivity, the CAMSR, and the EQ subscales of decentering and rumination. Additionally, there are significant negative relationships between the UPPSP subscale lack of sensation seeking and various measures of mindfulness including the MAAS, the FFMQ subscale of acting with awareness, the CAMSR, and the EQ subscales decenter and rumination. Finally, there is also a significant negative relationship between the UPPSP subscale perseverance and the FFMQ subscale of acting with awareness.

We graphed the simple slopes of the significant interactions (Figure 4). The interactions suggest that higher decentering (+1 *SD* of EQ decenter) relates to a higher lack of negative urgency and lower premeditation in the follicular phase, but for the luteal phase this relationship does not hold. In fact, for premeditation, higher EQ decentering is associated with higher premeditation in the luteal phase.

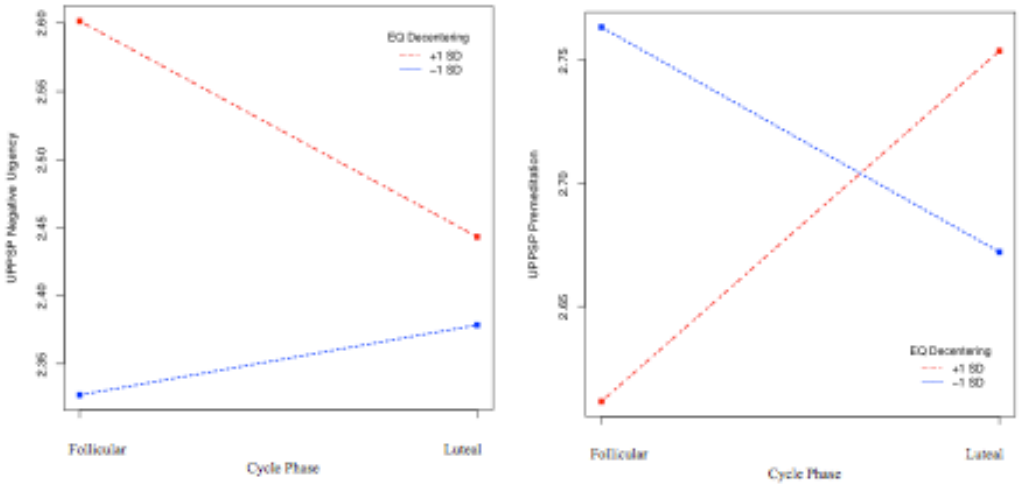
Table 5. Multiple regression coefficients assessing the moderation of the relationship between Menstrual Cycle Phase and UPPSP by mindfulness

	Negative Urgency					Premeditation					Perseverance					Sensation Seeking					Positive Urgency				
	B	*SE*	*p*	CI- 2.5%	97.5%	*B*	*SE*	*p*	CI- 2.5%	97.5%	*B*	*SE*	*p*	CI- 2.5%	97.5%	*B*	*SE*	*p*	CI- 2.5%	97.5%	*B*	*SE*	*p*	CI- 2.5%	97.5%
Luteal	0.269	0.326	0.429	-0.388	0.906	-0.333	0.372	0.373	-1.071	0.405	-0.047	0.277	0.907	-0.843	0.749	0.356	0.311	0.257	-0.264	0.976	-0.052	0.278	0.853	-0.604	0.500
MAAS	0.216	0.053	<0.001*	0.110	0.321	-0.155	0.061	0.012*	-0.276	-0.034	-0.086	0.065	0.193	-0.216	0.044	0.263	0.051	<0.001*	0.162	0.364	0.266	0.045	<0.001*	0.176	0.356
Luteal * MAAS	-0.066	0.077	0.39	-0.219	0.086	0.075	0.088	0.396	-0.099	0.249	-0.001	0.095	0.995	-0.188	0.187	-0.05	0.074	0.494	-0.197	0.096	0.006	0.0655	0.921	-0.124	0.137
Luteal	295	0.312	0.349	-0.332	0.923	-0.265	0.303	0.385	-0.873	0.343	-0.304	0.344	0.382	-0.996	0.388	0.358	0.305	0.246	-0.255	0.972	-0.162	0.273	0.556	-0.710	0.386
Act with Awareness	0.029	0.01	0.004*	0.010	0.048	-0.02	0.009	0.033*	-0.039	-0.002	-0.023	0.011	0.032*	-0.044	-0.002	0.021	0.009	0.029*	0.002	0.040	0.016	0.008	0.068	-0.001	0.032
Luteal * AWA	-0.016	0.014	0.264	-0.044	0.012	0.015	0.01	0.28	-0.012	0.042	0.017	0.015	0.271	-0.014	0.048	-0.001	0.014	0.521	-0.036	0.019	0.004	0.012	0.71	-0.020	0.029
Luteal	0.689	0.492	0.168	-0.300	1.678	-0.045	0.477	0.926	-1.003	0.914	-0.477	0.535	0.377	-1.552	0.598	0.364	0.483	0.455	-0.607	1.334	0.05	0.312	0.904	-0.779	0.879
Describe	0.029	0.012	0.021*	0.005	0.053	-0.006	0.011	0.606	-0.029	0.017	-0.001	0.013	0.941	-0.027	0.025	0.012	0.012	0.303	-0.011	0.036	0.023	0.01	0.029*	0.002	0.043
Luteal * Describe	-0.026	0.018	0.137	-0.062	0.009	0.003	0.017	0.844	-0.031	0.037	0.019	0.019	0.317	-0.019	0.058	-0.007	0.017	0.688	-0.041	0.028	-0.004	0.015	0.771	-0.034	0.025
Luteal	0.359	0.377	0.346	-0.399	1.117	-0.15	0.355	0.965	-0.728	0.697	-0.229	0.387	0.557	-1.006	0.549	0.471	0.36	0.198	-0.254	1.195	-0.044	0.321	0.891	-0.689	0.601
Observe	0.014	0.009	0.128	-0.004	0.031	0.001	0.008	0.932	-0.016	0.017	0.009	0.009	0.326	-0.009	0.027	0.005	0.008	0.552	-0.012	0.022	0.01	0.007	0.19	-0.005	0.025
Luteal * Observe	-0.015	0.013	0.282	-0.041	0.012	0.002	0.013	0.858	-0.023	0.028	0.01	0.014	0.454	-0.017	0.038	-0.011	0.013	0.4	-0.037	0.015	-0.001	0.011	0.951	-0.024	0.022
Luteal	0.227	0.383	0.556	-0.543	0.997	-0.367	0.349	0.298	-1.069	0.335	0.356	0.403	0.382	-0.454	1.165	0.512	0.357	0.158	-0.205	1.228	-0.099	0.326	0.762	-0.754	0.556
Non-Judgement	-0.003	0.011	0.756	-0.025	0.018	-0.015	0.001	0.138	-0.035	0.005	< 0.001	0.011	0.995	-0.023	0.023	0.016	0.01	0.119	-0.004	0.036	0.001	0.009	0.323	-0.009	0.028
Luteal * NJ	-0.012	0.017	0.484	-0.046	0.022	0.019	0.015	0.224	-0.012	0.050	-0.014	0.018	0.444	-0.049	0.022	-0.015	0.016	0.332	-0.047	0.016	0.002	0.014	0.904	-0.027	0.031
Luteal	0.018	0.43	0.68	-0.686	1.043	0.202	0.397	0.613	-0.595	0.999	0.156	0.445	0.728	-0.739	1.050	0.447	0.401	0.27	-0.359	1.252	0.266	0.344	0.443	-0.426	0.957
Non-reaction	-0.001	0.014	0.961	-0.028	0.027	0.001	0.13	0.964	-0.025	0.026	0.016	0.014	0.274	-0.013	0.044	-0.003	0.013	0.784	-0.029	0.022	0.028	0.011	0.013*	0.006	0.050
Luetal * NR	-0.01	0.02	0.616	-0.051	0.030	-0.007	0.019	0.689	-0.045	0.030	-0.005	0.021	0.813	-0.047	0.037	-0.013	0.019	0.493	-0.051	0.025	-0.16	0.016	0.326	-0.048	0.016

Luteal	0.264	0.242	0.278	-0.212	0.740	-0.36	0.248	0.148	-0.849	0.128	-0.149	0.278	0.592	-0.695	0.397	0.192	0.237	0.417	-0.274	0.658	-0.376	0.227	0.01	-0.822	0.069
CAMSR	0.027	0.004	< 0.001*	0.019	0.036	-0.009	0.005	0.05*	-0.018	<-0.001	0.002	0.005	0.843	-0.009	0.011	0.026	0.004	< 0.001*	0.018	0.035	0.028	0.004	< 0.001*	0.020	0.036
Luteal * CAMSR	-0.001	0.007	0.242	-0.022	0.005	0.001	0.007	0.016	-0.004	0.024	0.004	0.008	0.645	-0.012	0.019	0.007	0.007	0.918	-0.014	0.013	0.011	0.006	0.103	-0.002	0.023
Luteal	0.443	0.242	0.069	-0.034	0.919	-0.527	0.215	0.015*	-0.951	-0.104	-0.358	0.245	0.145	-0.839	0.124	0.42	0.218	0.056	-0.010	0.851	0.192	0.162	0.237	-0.128	0.513
EQ Decenter	0.015	0.004	< 0.001*	0.008	0.022	-0.008	0.003	0.013*	-0.015	-0.002	-0.003	0.004	0.454	-0.010	0.005	0.016	0.003	< 0.001*	0.009	0.022	0.026	0.002	< 0.001*	0.021	0.031
Luteal * Eqd	-0.011	0.001	0.037*	-0.022	-0.001	0.013	0.005	0.009*	0.003	0.022	0.009	0.005	0.9	-0.001	0.020	-0.006	0.005	0.232	-0.015	0.004	-0.006	0.004	0.11	-0.013	0.001
Luteal	0.015	0.322	0.962	-0.620	0.650	-0.25	0.279	0.368	-0.800	0.297	-0.233	0.314	0.458	-0.852	0.385	-0.414	0.295	0.162	-0.996	0.168	-0.243	0.26	0.351	-0.757	0.270
EQ Rumination	-0.007	0.001	0.439	-0.026	0.011	0.007	0.008	0.384	-0.009	0.024	0.008	0.009	0.391	-0.010	0.026	-0.024	0.009	0.007*	-0.041	-0.007	-0.035	0.008	< 0.001*	-0.050	-0.019
Luteal * EQR	-0.004	0.015	0.815	-0.033	0.026	0.013	0.013	0.301	-0.012	0.039	0.014	0.015	0.349	-0.015	0.043	0.027	0.014	0.05	0.000	0.054	0.008	0.012	0.525	-0.016	0.032

Note = Luteal = Cycle phase dummy code where Luteal = 1, MAAS = Mindful Attention Awareness Scale, AWA = Act with Awareness, CAMSR = Cognitive and Affective Mindfulness Scale Revised EQd = Experiences Questionnaire Decenter, EQr = Experiences Questionnaire Rumination

Figure 4. Interactions between UPPSP Negative Urgency and Premeditation and EQ Decentering



Cardiac Vagal Control

RSA

Multiple regressions were run with interactions to test if the relationship between menstrual cycle phase and RSA is moderated by mindfulness. In Table 6, you can see significant negative relationships between various RSA periods and mindfulness. First, there are significant negative relationships between RSA during Baseline 1-5 and the FFMQ subscales of acting with awareness and non-judgment. Additionally, there are significant negative relationships between RSA during Baseline 5-10 and the MAAS and the FFMQ subscale of acting with awareness. There are also significant negative relationships between the RSA during the CIA and the MAAS and the FFMQ subscale of act with awareness. Finally, there is a significant negative relationship between RSA during Recovery 1-5 and the MAAS and the FFMQ subscale act with awareness.

However, there were no significant interactions between RSA, cycle phase, and mindfulness.

Table 6. Multiple regression coefficients assessing the moderation of the relationship between Menstrual Cycle Phase and RSA by mindfulness

	Baseline 1-5					Baseline 5-10					CIA testing					Recovery 1-5					Recovery 5-10				
	B	*SE*	*p*	CI- 2.5%	97.5%	*B*	*SE*	*p*	CI- 2.5%	97.5%	*B*	*SE*	*p*	CI- 2.5%	97.5%	*B*	*SE*	*p*	CI- 2.5%	97.5%	*B*	*SE*	*p*	CI- 2.5%	97.5%
Luteal	-0.965	1.323	0.468	-3.604	1.674	-1.169	1.264	0.358	-3.689	1.350	-1.461	1.215	0.233	-3.885	0.963	-1.268	1.199	0.294	-3.658	1.123	-0.952	1.22	0.438	-3.386	1.482
MAAS	-0.390	0.205	0.061	-0.799	0.018	-0.424	0.196	0.033*	-0.814	-0.034	-0.424	0.188	0.028*	-0.799	-0.048	-0.412	0.186	0.03*	-0.782	-0.041	-0.335	0.1889	0.08	-0.712	0.042
Luteal * MAAS	0.193	0.309	0.535	-0.424	0.809	0.235	0.295	0.428	-0.354	0.824	0.32	0.284	0.264	-0.247	0.886	0.252	0.28	0.371	-0.306	0.811	0.188	0.285	0.512	-0.381	0.756
Luteal	-1.456	1.099	0.193	-3.679	0.768	-1.143	1.068	0.291	-3.304	1.017	-1.352	1.02	0.193	-3.415	0.710	-1.145	1.001	0.26	-3.171	0.880	-0.845	1.039	0.421	-2.946	1.257
Act with Awareness	-0.07	0.031	0.028*	-0.132	-0.008	-0.065	0.03	0.035*	-0.126	-0.005	-0.071	0.028	0.017*	-0.128	-0.013	-0.067	0.028	0.022*	-0.123	-0.010	-0.56	0.029	0.06	-0.115	0.002
Luteal * AWA	0.059	0.049	0.234	-0.040	0.157	0.045	0.047	0.342	-0.050	0.141	0.061	10.045	0.1834	-0.030	0.152	0.052	0.044	0.246	-0.037	0.142	0.04	0.046	0.392	-0.053	0.133
Luteal	-1.463	1.627	0.374	-4.754	1.828	-1.917	1.558	0.226	-5.068	1.233	-1.719	1.513	0.263	-4.781	1.342	-1.84	1.49	0.224	-4.855	1.175	-1.566	1.5	0.302	-4.593	1.461
Describe	-0.052	0.04	0.202	-0.134	0.029	-0.064	0.039	0.106	-0.142	0.014	-0.058	0.037	0.131	-0.134	0.018	-0.045	0.037	0.226	-0.120	0.029	-0.061	0.037	0.109	-0.136	0.014
Luteal * Describe	0.44	0.057	0.441	-0.071	0.160	0.061	0.055	0.267	-0.049	0.172	0.059	0.053	0.273	-0.048	0.166	0.064	0.052	0.229	-0.042	0.170	0.055	0.052	0.298	-0.051	0.162
Luteal	0.778	1.227	0.53	-1.704	3.259	0.658	1.19	0.583	-1.748	3.064	0.048	1.168	0.967	-2.315	2.412	0.215	1.143	0.852	-2.098	2.528	0.285	1.156	0.807	-2.054	2.624
Observe	-0.014	0.028	0.628	-0.071	0.043	-0.016	0.027	0.562	-0.071	0.039	-0.022	0.027	0.423	-0.076	0.033	-0.018	0.026	0.508	-0.071	0.036	-0.02	0.027	0.453	-0.074	0.034
Luteal * Observe	-0.036	0.043	0.401	-0.123	0.050	-0.031	0.042	0.456	-0.115	0.053	-0.004	0.041	0.914	-0.087	0.078	-0.01	0.04	0.806	-0.091	0.071	-0.011	0.04	0.784	-0.093	0.070
Luteal	-1.8	1.106	0.189	-3.717	0.758	-1.071	1.085	0.33	-3.265	1.123	-1.022	1.048	0.336	-3.142	1.099	-0.671	1.015	0.513	-2.724	1.383	-0.82	1.049	0.439	-2.943	1.303
Non-Judgement	-0.063	0.031	0.048*	-0.126	-0.001	-0.053	0.03	0.087	-0.114	0.008	-0.053	0.029	0.08	-0.112	0.007	-0.053	0.028	0.068	-0.110	0.004	-0.047	0.029	0.12	-0.106	0.013
Luteal * NJ	0.057	0.048	0.242	-0.040	0.153	0.039	0.047	0.4506	-0.055	0.134	0.043	0.045	0.358	-0.049	0.134	0.028	0.044	0.528	-0.061	0.116	0.036	0.045	0.429	-0.055	0.128
Luteal	0.146	1.335	0.914	-2.555	2.846	0.12788	1.292	0.922	-2.486	2.742	0.377	1.249	0.765	-2.149	2.902	0.103	1.222	0.934	-2.369	2.574	0.289	1.244	0.817	-2.228	2.806
Non-reaction	0.022	0.042	0.601	-0.064	0.108	0.024	0.041	0.557	-0.059	0.107	0.027	0.04	0.498	-0.053	0.108	0.021	0.039	0.601	-0.058	0.099	0.017	0.04	0.677	-0.063	0.097
Luetal * NR	-0.018	0.062	0.777	-0.144	0.108	-0.016	0.06	0.794	-0.138	0.106	-0.022	0.058	0.714	-0.139	0.096	-0.008	0.057	0.895	-0.123	0.108	-0.015	0.058	0.799	-0.132	0.103
Luteal	-1.875	1.89	0.325	-5.645	1.895	-1.282	1.826	0.485	-4.925	2.360	-1.784	1.753	0.312	-5.280	1.712	-1.501	1.73	0.388	-4.951	1.948	-1.538	1.742	0.38	-5.011	1.936
CAMSR	-0.055	0.034	0.112	-0.123	0.013	-0.045	0.033	0.177	-0.110	0.021	-0.046	0.032	0.145	-0.109	0.016	-0.046	0.031	0.142	-0.108	0.016	-0.045	0.031	0.157	-0.107	0.018
Luteal * CAMSR	0.049	0.054	0.367	-0.058	0.155	0.031	0.052	0.552	-0.072	0.134	0.047	0.05	0.346	-0.052	0.146	0.036	0.049	0.459	-0.061	0.134	0.039	0.049	0.433	-0.060	0.137

Luteal	-1.41	1.55	0.369	-4.553	1.731	-1.558	1.513	0.309	-4.618	1.502	-1.544	1.46	0.297	-4.496	1.408	-1.507	1.422	0.296	-4.383	1.370	-1.106	1.441	0.447	-4.020	1.808
EQ Decenter	-0.037	0.024	0.13	-0.085	0.011	-0.034	0.023	0.151	-0.081	0.013	-0.035	0.022	0.131	-0.080	0.011	-0.035	0.022	0.113	-0.080	0.009	-0.036	0.022	0.113	-0.081	0.009
Luteal * Eqd	0.027	0.034	0.442	-0.043	0.097	0.031	0.034	0.367	-0.037	0.099	0.033	0.032	0.31	-0.032	0.099	0.033	0.032	0.305	-0.031	0.097	0.448	0.032	0.448	-0.040	0.089
Luteal	1.217	2.057	0.558	-2.944	5.378	-0.107	1.999	0.958	-4.151	3.937	-0.227	1.932	0.907	-4.136	3.682	0.14	1.898	0.942	-3.699	3.979	-0.28	1.923	0.885	-4.170	3.609
EQ Rumination	0.017	0.061	0.777	-0.106	0.141	-0.024	0.059	0.684	-0.145	0.096	-0.031	0.057	0.592	-0.147	0.085	-0.002	0.056	0.965	-0.117	0.112	-0.025	0.057	0.661	-0.141	0.090
Luteal * EQR	-0.068	0.096	0.48	-0.262	0.125	-0.005	0.093	0.955	-0.193	0.183	0.007	0.09	0.943	-0.175	0.188	-0.009	0.088	0.925	-0.188	0.169	0.012	0.09	0.897	-0.169	0.193

Note = Luteal = Cycle phase dummy code where Luteal = 1, MAAS = Mindful Attention Awareness Scale, AWA = Act with Awareness, CAMSR = Cognitive and Affective Mindfulness Scale Revised. EQd = Experiences Questionnaire Decenter, EQr = Experiences Questionnaire Rumination

Alcohol

Multiple logistic regressions were run with interactions to test if the relationship between menstrual cycle phase and any alcohol use is moderated by mindfulness. No significant relationships between menstrual cycle phase, Alcohol use, and the MAAS, the CAMSR, the EQ, and all factors of the FMMQ were statistically or substantively significant were found (Table 7).

Table 7. Multiple logistic regression coefficients assessing the moderation of the relationship between Menstrual Cycle Phase and Alcohol by mindfulness

	B	*SE*	*p*	CI- 2.5%	97.5%
Luteal	-1.767	2.686	0.511	-7.250	3.424
MAAS	-0.206	0.401	0.608	-1.019	0.578
Luteal * MAAS	0.325	0.635	0.608	-0.922	1.597
Luteal	0.153	1.874	0.935	-3.619	3.895
Act with Awareness	0.014	0.057	0.813	-0.100	0.131
Luteal * AWA	-0.015	0.084	0.859	-0.183	0.153
Luteal	2.325	3.128	0.457	-3.768	8.707
Describe	0.042	0.072	0.562	-0.097	0.193
Luteal * Describe	-0.089	0.110	0.419	-0.315	0.125
Luteal	3.255	2.257	0.149	-0.978	8.068
Observe	0.009	0.050	0.855	-0.089	0.110
Luteal * Observe	-0.131	0.084	0.117	-0.313	0.024
Luteal	-0.279	2.072	0.893	-4.456	3.886
Non-Judgement	-0.052	0.061	0.396	-0.182	0.066
Luteal * NJ	0.006	0.091	0.950	-0.178	0.188
Luteal	5.080	2.749	0.065	0.004	11.019
Non-reaction	0.031	0.076	0.682	-0.117	0.187
Luetal * NR	-0.256	0.131	0.051	-0.539	-0.014
Luteal	4.118	3.910	0.292	-3.286	12.290
CAMSR	0.000	0.062	0.994	-0.123	0.123
Luteal * CAMSR	0.134	0.116	0.249	-0.381	0.082
Luteal	3.556	3.087	0.249	-2.291	10.059
EQ Decenter	-0.025	0.042	0.549	-0.111	0.057
Luteal * Eqd	-0.087	0.071	0.223	-0.238	0.047

Luteal	-1.370	4.357	0.753	-10.556	7.016
EQ Rumination	0.185	0.120	0.123	-0.037	0.447
Luteal * EQR	0.058	0.200	0.773	-0.329	0.476

Note = Luteal = Cycle phase dummy code where Luteal = 1, MAAS = Mindful Attention Awareness Scale, AWA = Act with Awareness, CAMSR = Cognitive and Affective Mindfulness Scale Revised, EQd = Experiences Questionnaire Decenter, EQr = Experiences Questionnaire Rumination

5. Discussion

The first aim assessed cycle phase differences in impulsivity, CVC, and alcohol. The only significant difference was for sensation seeking, which was higher in the luteal phase. As a trend, this lends little support to suggest that impulsivity varies much by cycle phase. However, there is research to suggest that sensation seeking is a particularly important predictor of alcohol consumption independent of other components of impulsivity (Magid, MacLean, & Colder, 2007). Additionally, considering mindfulness' influence on sensation seeking reveals additional trends, as discussed below. Given that sensation seeking is tied to alcohol use, this may suggest that women are more vulnerable to alcohol consumption during the luteal phase. However, this could also indicate that women who are not pregnant, or currently able to become pregnant (as the late luteal phase is outside of the ovulation window), are more sensitive to experiences that are exciting and reinforcing. This may mean women are inspired to "go for it" when not at risk of becoming a mother. Thus, the luteal phase could potentially provide women with an adaptive opportunity to try new, exciting, or risky ventures. Given the uncertainty of what the relationship between sensation seeking and cycle phase may mean, more research should continue to examine sensation seeking's relationship with menstrual cycle phase and adaptive and maladaptive risk taking.

The second aim looked at mindfulness as a moderator of the relationship between menstrual cycle phase and alcohol consumption and risk factors. First, of note, none of the relationships with alcohol consumption were significant. Given the sample size and lack of

alcohol consumption in the sample obtained in this study, it is impossible to argue the null. Given the wide variability of results on the relationship between menstrual cycle phase and alcohol consumption, it is also hard to compare or contrast these finding against existing research (Carroll et al., 2015). Yet, the null findings here in combination with mixed results on alcohol use and menstrual cycle phase in other research suggests that menstrual cycle may not be a robust factor in alcohol consumption. In general, this supports movements to include women in research on alcohol use and suggests that if there are sex differences in alcohol consumption, menstrual cycle phase is not a major contributor to those differences. The present study also looked at risk factors for alcohol consumption, and while there were very few significant interactions with menstrual cycle phase, some general trends emerged for risk factors for alcohol consumption and mindfulness.

First, delay discounting, as measured by the CIA, was influenced by the mindfulness EQ measure. Specifically, both decentering and rumination were related to more preference for SIR for average and small sized rewards, and rumination was additionally related to more preference for SIR for medium sized rewards. As a measure of attention control, the EQ focuses on meta-cognitive decentering and the cognitive rumination elements of mindfulness. Thus, higher decentering, or the meta-cognitive ability to observe your thoughts while keeping distance from them, and higher rumination, or thinking too much about the consequences of decisions, was related to higher, or more impulsive, delay discounting choices. First, the finding that decentering was positively related to impulsivity is a bit counterintuitive. One might expect that decentering would allow one to take a step back from the decision at hand and choose the more logical and beneficial LDR. While most other studies have found that decentering and impulsivity are negatively related, at least one other study did find a positive relationship between measures of impulsivity and decentering (Vinci et al., 2016). However, the Vinci and colleagues

study looked at state mindfulness. Ultimately, the slopes for decentering are very small, suggesting the effect is minimal. Next, the finding that rumination was related to more preference for SIR is more intuitive. We might expect that thinking too much about any choice will push decisions towards the more immediate and salient option. Indeed it maybe that engagement with your thoughts in either a preoccupied or detached way brings salience to the more immediate reinforcement.

Considering the EQ and impulsivity, menstrual cycle phase was not influential in the relationship between decentering and delay discounting, but rumination significantly moderated the relationship between delay discounting and luteal phase such that higher rumination was related to more preference for SIR for women in their follicular phase, but not in the luteal phase. This suggests that the relationship between rumination and impulsive choices might be more important for women in the follicular phase to avoid impulsive choice making. First, this finding suggests that luteal phase delay discounting is unaffected by rumination. This provides further support to suggest that the luteal phase is not a particularly risk sensitive period for women. In fact, it appears that women in the follicular phase might require more mindful skills in order to make choices for LDR. Women may be more sensitive to rumination in the follicular phase for many different reasons. One possibility is neurobiological changes in gamma-aminobutyric acid (GABA). GABA is an inhibitory nuerotransmitor in that brain that prevents synaptic firing. Higher levels of inhibition, associated with GABA, have been found in the luteal phase for women (Smith et al., 1999). Thus, thinking in the luteal phase requires more cognitive focus. Given that women in the follicular phase are coming off this time of heavy cognitive processing, thinking may feel relatively less effortful. Therefore, the type of thinking about your thinking we find in rumination may come easily and require more mindful skill to intervene

in. However, this is the first study to look at delay discounting as associated with the EQ, so further research is needed.

The UPPSP was associated with nearly every measure of mindfulness. Lack of negative urgency was positively related to the MASS, acting with awareness, describe, non-react, the CAMSR, and EQ decentering. Premeditation was negatively related to the MAAS, acting with awareness, the CAMSR, and the EQ decentering. Lack of positive urgency was positively related to the MAAS, describe, non-react, the CAMSR, the EQ decentering, and the EQ rumination. Lack of sensation seeking was negatively related to the MAAS, acting with awareness, the EQ decentering, and the EQ rumination. Perseverance was negatively related to acting with awareness. This suggests that being more mindful is related to having lower negative urgency and premeditation and higher perseverance, sensation seeking and positive urgency.

The relationships between negative urgency and perseverance are as expected. Those with higher mindfulness are likely to persevere more in tasks and be less likely to act out from a place of negative emotionality. Other research investigating the UPPSP in relation to mindfulness found negative relationships between mindfulness and impulsivity, which matches with some of our findings, but not others (Peters, Erisman, Upton, Baer, & Roemer, 2011; Williams & Grisham, 2012). Specifically, the relationships with premeditation, sensation seeking, and positive urgency are not as hypothesized. Yet, while these findings are not as expected, the patterns are consistent within our results and match some other research.

In particular, in support of our findings that sensation seeking is positively related to mindfulness and premeditation is negatively related to mindfulness, one study of alcohol consumption, impulsivity, and mindfulness in a college drinking sample also found a positive relationship between sensation seeking and mindfulness, and negative relationship

between premeditation and mindfulness (Murphy & MacKillop, 2012). For sensation seeking, it makes intuitive sense that liking new and exciting experiences would relate to awareness of your experiences. Indeed, one study found that following a brief mindfulness intervention for problem alcohol use, those who were initially high in sensation seeking were more likely to have higher levels of negative affect after the intervention (Vinci et al., 2016). This suggests that when sensation seeking is high and mindfulness is invoked, the focus may not always be on the positive aspect of emotional affect. In regard to premeditation, there is also some logic to mindfulness being negatively related to premeditation. Mindfulness is by definition present-focused, and theoretically should be higher when one is not preoccupied thinking about experiences that one is going to have. In particular, mindfulness encourages participants to bring attention to each experience as if it were the first time you experienced it. This component of mindfulness is uniquely similar to the concept of premeditation. A lack of premeditation is characterized by not thinking about the future, therefore, being more focused on the sensation and reward in the present. In combination, these findings lends further support to suggest that impulsivity and mindfulness may not have a clean inverse relationship, but rather certain factors of impulsivity might be more important or risky than others.

Additionally, the relationship between menstrual cycle phase and negative urgency was significantly moderated by decentering, such that higher decentering was related to lower negative urgency in the follicular phase, but not in the luteal. The relationship between menstrual cycle phase and premeditation was also significantly moderated by decentering such that higher decentering was related to lower premeditation in the follicular phase, and higher decentering was related to higher premeditation in the luteal phase. For negative urgency, this suggests that these negative relationships between negative urgency and EQ decentering hold for the follicular phase but not the luteal phase. Thus, the ability to

evince the skill of decentering, or put labels to your experiences, might be more important for women in the follicular phase in regards to taking rash action based on negative affect. Again, looking to our GABA hypothesis, if women are more prone to thinking and processing in the follicular phase, being able to take a step back from these thoughts might be of particular importance in the follicular phase. For instance, imagine a woman experiences negative affect follicularly that results in an impulse to react rashly, as in negative urgency. Being able to slow that thinking in the particularly "quick thinking" follicular phase, label the negative affect or thought, and provide space for another more healthy choice may be more beneficial than in the luteal phase.

In contrast, for premeditation, higher decentering relates to less thinking about the future in the follicular phase. Conceptually, premeditation is more related to decentering than some of the other factors of impulsivity. Decentering is stepping back from your thoughts in the present to create more space in the moment, whereas premeditation is allowing yourself to think about how your present may affect the future. So, it may be possible to decenter yourself out of premeditation, such that you are so focused on the present that you don't think about the future and act according to the moment. In the follicular phase, decentering might be functioning in this manner. Luteally, the relationship between decentering and premeditation is as expected. When women are able to take a step back from their thoughts in the luteal phase they are also more likely to see how their current actions relate to the future. Overall, these findings suggest that for freely cycling women, there might be different patterns of relationships between some aspects of mindfulness and impulsivity.

For the psychophysiological results, MAAS was negatively related to RSA in the second period of baseline, the CIA period, and the first period of recovery. Acting with awareness was negatively related to RSA in the first and second period of baseline, the CIA

period, and the first period of recovery. These results are in direct opposition to our hypothesis, and prior research in this area (e.g., Brewer et al., 2009).One possible explanation for this discrepancy is that other studies of mindfulness and CVC have used different estimations of CVC. A few studies used HF-HRV (Brewer et al., 2009; Libby, Worhunsky, Pilver, & Brewer, 2012), where another used an estimation of HF-HRV (Garland et al., 2010). Thus, this is the first study to use RSA as a measure of CVC. All of these measures of CVC use different analytic approaches, and could potentially result in different outcomes. Moreover, most of the previous studies on CVC and mindfulness have been conducted in samples following a mindfulness based therapy program (Brewer et al., 2009; Libby, Worhunsky, Pilver, & Brewer, 2012) or during mindfulness meditation (Ditto, Eclache, & Goldman, 2006). Research with trait mindfulness reveals more mixed findings.

Only one study looked at one measure of CVC, an estimation of HF-HRV called Root Mean Square of the Successive Differences (RMSSD), as related to trait mindfulness in individuals with alcohol use disorders (Garland et al., 2010). Participants completed a stress inducing alcohol cue exposure task, and RMSSD was measured during baseline, task, and recovery. Trait mindfulness was only related to RMSSD recovery, but not baseline or reactivity RMSSD. While we did not find any effect of mindfulness on recovery RSA, Garland's results are more in line with our findings regarding RSA. Given the plethora of information on CVC and treatment induced mindfulness connections, the lack of information on CVC and dispositional mindfulness may indicate a null, file drawer problem, or a legitimate lack of research into CVC and trait mindfulness. In some ways these findings may be encouraging for mindfulness-based treatments, suggesting that there is something unique about mindfulness after mindfulness-based treatments that relates to psychophysiological engagement with stress. Future research should continue to investigate

the relationship between psychophysiological engagement with stress, mindfulness, and alcohol use.

Limitations

While this study offers ideal estimates of menstrual cycle phase, it is not without limitations. Given the error with the UPPSP measures, all of these results should be interpreted with great caution. Our findings with the UPPSP are mostly in line with prior literature, which provides some reassurance that the measure was still accurate. Additionally, the low level of alcohol consumption by participants in the study makes it difficult to assess the relationship between menstrual cycle phase and alcohol consumption. While these results may suggest that in the general population menstrual cycle is not related to alcohol consumption, it is difficult to say with so little alcohol consumption occurring. Replication in a clinical sample is important for understanding alcohol consumption in women as related to alcohol use disorders. Finally, there are several ways of estimating CVC, and RSA is only one of them. A different method of estimating CVC might have resulted in different findings, as each method of estimation comes a set of limitations. More research is needed on mindfulness as related to different measures of CVC.

Conclusions

In summary, the present study investigates the influence of menstrual cycle on alcohol consumption, impulsivity, and CVC, with attention control as a moderator. Overall, there was little evidence to suggest that the luteal phase is a risk period for risk-taking or increased alcohol consumption. Specifically, there is no evidence of cycle differences in alcohol consumption, impulsivity or CVC, except in the case of sensation seeking; which is higher in the luteal phase. Accordingly, there was little evidence of attention control moderating the relationship between menstrual cycle phase and alcohol consumption, impulsivity, and CVC, except for with decentering and rumination. This provides some

evidence to suggest that factors of attention control might be more related to impulsive decision making in the follicular phase. Additionally, the positive relationships found between attention control and impulsivity and CVC were unexpected, but lend support to a developing group of studies that show that mindfulness is not inversely related with all factors of impulsive decision making, and some factors of mindfulness are potentially more effective than others in regard to impulsive decision making and CVC. As expected, lower levels of negative urgency, premeditation, perseverance, and sensation seeking were associated with higher levels of attention control. However, unexpectedly, higher levels of positive urgency and delay discounting were associated with higher levels of attention control. Finally, there were main effects of attention control on CVC such that lower levels of RSA throughout the experiment were related to higher levels of mindfulness. In particular, RSA was negatively related to the MAAS, the FFMQ factor of acting with awareness, rumination and decentering. These findings suggest that trait mindfulness does not function in the same manner as treatment-evinced mindfulness in regard to psychophysiological responses.

Overall, these findings suggest that the relationships between impulsivity, CVC, and attention control are complex in freely cycling women, and menstrual cycle phase contributes to some minor aspects of these relationships. However, in general, menstrual cycle phase does not appear to be a robust contributor to alcohol consumption, impulsivity, or CVC in freely cycling women. This provides support to suggest that the menstrual cycle, namely the luteal phase, is not a pathological period of risk or vulnerability. Researchers should not be afraid to include women in studies of alcohol consumption and other risk behaviors due to their menstrual cycle, and instead, should continue to seek to identify sex differences in mechanisms of alcohol consumption and other risk taking behaviors.

4. ATLAS Project: Moderation of Relation between Psychological Risk Factors and Alcohol Use by Sex and Premenstrual Symptoms

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Prepared for Psychology of Addictive Behaviors

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1. Introduction

Alcohol use is a significant public health concern, being one of the largest contributors to global disease burden (Lim et al., 2012). Of particular concern, adolescent alcohol use is a predictor for alcohol use and dependence in adulthood (Grant et al., 2005). Indeed, evidence suggests that higher use in adolescence continues into adulthood (McCambridge, McAlaney, & Rowe, 2011). Moreover, recent epidemiological research suggests that in younger cohorts women are catching up to men in alcohol use and negative consequences (Slade et al., 2016). Historically, alcohol use in women is understudied (Institute of Medicine (IOM), 2010a). In particular, the relationship between menstrual cycle related factors and alcohol use are not well understood (Carroll, Lustyk, & Larimer, 2015). Thus, understanding the impact of sex on alcohol use in young adults can have important implications for prevention of alcohol dependence later in life. Researchers have identified that the most effective way to target alcohol use in adolescents is through risk factors (Hawkins, Catalano, & Miller, 1992). While risk factors encompass a wide range of environments and behaviors, such as laws surrounding liquor control, the present study focuses on individual psychological risk factors. There is some evidence that individual psychological factors can also be protective against alcohol use, more research is needed in this area (Hawkins et al., 1992). Thus the present study investigates individual

psychological risk factors and protective factors related to sex and alcohol use in young adults.

Research is somewhat mixed on sex differences in alcohol use. In the last few decades, a strong body of research has accumulated to suggest that women consume less alcohol but suffer more consequences of alcohol use than men (Nolen-Hoeksema, 2004). The term "telescoping" has been used to describe an observed trend whereby women transition more quickly from initial drink to alcohol use disorders than men. However, recent time series analyses has called telescoping into question, suggesting that telescoping actually happens in the reverse- men are more likely to develop alcohol use disorders more quickly than women (Keyes et al., 2010). Given prior cited epidemiological evidence that women have been catching up with men in alcohol use over the last few cohorts (Brady & Randall, 1999; Keyes et al., 2010; Slade et al., 2016), patterns of alcohol use by sex may be changing over time.

In regard to menstrual cycle, research on menstrual cycle and alcohol use has produced mixed findings (Carroll et al., 2015). There is not enough evidence to suggest that alcohol use varies by cycle within women in any particular direction. However, between women, premenstrual symptoms have been found to relate to higher levels of alcohol use, though the strength of this relationship varies (Deuster, Adera, & South-Paul, 1999; Mello, Mendelson, & Lex, 1990b). Thus, in addition to sex differences, the present study looks at premenstrual symptoms in women and how individual risk factors interact with premenstrual symptoms to affect alcohol use.

Of the individual personality risk factors that relate to alcohol use, disinhibition, or impulsivity and sensation seeking, is a well studied one (Dick et al., 2010). Impulsivity is characterized by carelessness, rapid decision making, with a lack of reflectiveness and planning (Schalling, 1978). Sensation seeking is defined by the need for varied, novel, and

stimulating experiences (Zuckerman, 1979). While some impulsivity measures include sensation seeking, such as the five factor UPPSP (Lyman et al., 2006), evidence suggests that sensation seeking contributes uniquely to alcohol use, whereas impulsivity is related to alcohol related negative consequences (Magid et al., 2007). When assessed, sex has mostly been found to moderate the relationship between impulsivity, sensation seeking, and alcohol. One study found that the relationship between impulsivity and alcohol related problems was strongest for men (Stoltenberg, Batien, & Birdenheir, 2008). In another, sensation seeking was not found to relate to alcohol use in men, but was related for women (Magid et al., 2007). In yet another, impulsivity was weakly related to drinking in both men and women (Balodis, Potenza, & Olmstead, 2009). However, no study to date has investigated how impulsivity related to premenstrual symptoms and alcohol use.

In contrast to impulsivity, mindfulness is defined as the ability to pay attention, on purpose, with non-judgment (Kabat-Zinn, 1990). Burgeoning research has looked at mindfulness related to alcohol use, and mindfulness has been used therapeutically with alcohol and other substance use disorders (Sarah Bowen et al., 2009; Brewer et al., 2009; Garland et al., 2010). Both mindfulness and impulsivity include some facets of present-minded thinking. However, where mindfulness focuses on the passing nature of impulses, impulsivity is characterized by a lack of concern for the future. Although there is some limited evidence to suggest that lower impulsivity accounts for the relationship between mindfulness and alcohol use (Murphy & MacKillop, 2012), we are interested in mindfulness as an independent protective factor.

Regarding the relationship between mindfulness and sex, due to some concern that mindfulness may be related to more traditional feminine social roles, a systematic review investigated the impact of sex on mindfulness treatments for alcohol use (Katz & Toner, 2013). However, of 36 eligible studies, only 6 studies included sex in analyses. Within the 6

studies included, there was some evidence that women may benefit more from mindfulness-based treatments for alcohol use. However, more research is needed in this area. Additionally, one study investigating the relationship between premenstrual symptoms and mindfulness found that higher levels of mindfulness are related to lower levels of premenstrual symptoms (Lustyk, Gerrish, Douglas, Bowen, & Marlatt, 2011). Thus the present study investigates sex and premenstrual symptoms in women as potential moderators of the relation between mindfulness and alcohol use.

1.5 Purpose and Hypothesis

The present study investigates sex differences in individual psychological risk factors for alcohol use and alcohol related negative consequences in young adults. First, we will investigate sex differences in alcohol use and alcohol related negative consequences. In line with historical findings, we hypothesize that men will consume more alcohol with more negative consequences that women. Then we will investigate sex as a potential moderator in previously demonstrated relationships between the risk factor of impulsivity and the protective factor of mindfulness onto alcohol use. Given the weak or mixed evidence for sex differences between impulsivity and mindfulness on alcohol use- we do not have a-priori hypothesis. Next, to investigate the relationship between premenstrual symptoms and alcohol use and alcohol related negative consequences we will subset the available data to look only at women. First, we will investigate the effect of premenstrual symptoms on alcohol use and alcohol related negative consequences. In line with the limited research available, we hypothesize that higher premenstrual symptomatology will relate to higher alcohol use and more negative consequences. Finally, we will investigate the effect of premenstrual symptomatology on the previously demonstrated relationships between the risk factor of impulsivity and the protective factor of mindfulness onto alcohol use. This is an exploratory research question without an a-priori hypothesis.

2. Methods

2.1 Procedure

The present study utilizes survey data from a large international trial assessing alcohol use trajectories in young adults in the United States and Sweden. In order to minimize cultural differences in alcohol use (as elucidated in other research comparing the US and Sweden (Ståhlbrandt et al., 2008) and results from this trial; Carroll et al., 2016), we only included participants from the United States.

While methods from this study have been published elsewhere (Grazioli et al., 2015), we describe them in brief here. After approval from institutional IRB, researchers administered a baseline survey to assenting 17-year old and consenting 18-year old high school seniors in the state of Washington, United States (N = 1,181, 42.3% Male) for a 4-year study assessing alcohol use trajectories. Half of the participants were then randomized to receive a brief online intervention using personalized normative feedback. Given that initial results suggest that this intervention is effective in reducing alcohol use, we did not include any participants randomized into the intervention; only control group participants were included. All participants were sent follow up online interviews assessing alcohol use trajectories every 6 months following baseline. The present study utilizes some demographic information from baseline, and outcome and covariate information gathered during the 12-month and 18-month follow-up surveys.

2.2 Measures

2.2.1 Demographics

Participant self-reported **sex** (42.3% Male), and **race** (70.5% Caucasian) were collected at baseline. Participant monthly **income** was collected at the 12-month follow up (nominal variable, mean income reported was in the $200-400 range, median income reported was in the $100-200 range). Participant **age** was collected at the 18-month follow

up (M = 19.57, SD = 0.73) in order to control for age at the time that the alcohol use outcomes were measured.

2.2.2 Outcome Variables

2.2.2.a Quantity/Frequency of Alcohol Use

Quantity

Participants reported the quantity of alcohol they drank during a typical occasion (**Typical BAC**) and during a peak occasion (**Peak BAC**) during the last month. BAC was calculated based on sex, weight, number of drinks reported drinking and hours spent drinking. BAC is highly non-normal, zero inflated, overdispersed, and highly negatively skewed, and essentially a rate of drinks consumed over time. Thus to be able to analyze with zero-inflated modeling techniques, we transformed BAC into a count variable. To do this, we multiplied the calculated BAC by one hundred and rounded to the nearest whole number. Other research using of BAC in count variable models has utilized this same transformation (Neighbors et al., 2011).

Frequency

Participants reported the number drinks they consumed each day of the week for the last month (i.e., On a typical Monday I have … drinks). We then aggregated these data to calculate the number of days the participant spent drinking in a typical week in the past month (**Drink Days**) and the total number of drinks they consumed in a typical week (**Total Drinks Week**).

2.2.2.b Alcohol Related Negative Consequences

*Young Adult Alcohol Problem Screening Test (**YAAPST**)*

Participants completed the YAAPST at the 18-month follow up. The YAAPST (Hurlbut & Sher, 1992) includes 18 experiences that have occurred after drinking in the last three months (e.g., headache). Participants identified the frequency with which each

experience occurred after drinking. We then converted the frequency to a binary indicator of whether or not each experience occurred in the last three months to compute a count of alcohol related negative consequences experiences by each participant.

*Rutgers Alcohol Problem Index (**RAPI**)*

Participants completed the RAPI at the 18-month follow up. The RAPI (Neal, Corbin, & Fromme, 2006) includes 26 events (e.g., had a fight) that occurred due to drinking in the last 3 months. Participants identified the frequency with which each event occurred after drinking. We then converted the frequency to a binary indicator of whether or not each event occurred in the last three months to compute a count of alcohol related negative consequences experiences by each participant. Prior research has suggested that the dichotomous RAPI score for three subscales of **abuse/dependence** (e.g., felt you had a problem with alcohol), **personal consequences** (e.g., neglected your responsibilities), and **social consequences** (e.g., had a bad time) are reliable and valid (Martens, Neighbors, Dams-O'Connor, Lee, & Larimer, 2007). Thus, the present study utilized these subscales.

2.2.3 Covariates

2.2.3.a Mindfulness

*Cognitive and Affective Mindfulness Scale- Revised (**CAMS-R**)*

Participants completed the CAMS-R at the 12-month follow up period. The CAMS-R (Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007) is a 12-item nominal scale. Participants respond to how much (1 = Rarely/Not at all; 4 = Almost always) each item (e.g., I can tolerate emotional pain) applies to them. The items are summed, and a higher score indicates a higher level of dispositional mindfulness.

2.2.3.b Impulsivity

Impulsive Sensation Seeking Scale from Zuckerman Kuhlman Personality Questionnaire

Participants completed the Impulsive Sensation Seeking Scale in the 12-month follow up survey. The Impulsive Sensation Seeking Scale (Zuckerman, 1979) is 19 items. Participants indicate whether each item is true or false for them. The items are then summed into two subscales: Impulsivity (**Impulsivity**, 7 items, e.g., I am an impulsive person) and Sensation Seeking (**Sensation Seeking**, 12 items, e.g., I'll try anything once). A higher score on the Impulsivity and Sensation Seeking scales indicates higher levels of impulsivity and sensation seeking, respectively.

2.2.3.c Premenstrual Symptoms

*Shortened Premenstrual Assessment Form (**SPAF**)*

Participants completed the SPAF in the 12-month follow up survey. The SPAF (Allen, McBride, & Pirie, 1991) is a clinical tool that includes 10 symptom items in which participants indicate the severity of change (1 = No change, 6 = Extreme Change) in symptoms (e.g., feeling under stress) in the seven days prior to their last menstrual cycle. The items are summed into a summary score, where a higher score indicates more severe premenstrual symptoms.

4. Results

4.1 Data analysis

Race reported at baseline, income reported at 12-months, and age reported at 18-months were controlled for in all analyses. All of the alcohol related outcomes in the present analyses are count outcomes. Given the tendency of alcohol related outcomes to be zero inflated, which was confirmed by visual inspection and variance statistics (see Table 1), we conducted Poisson, Zero Inflated Poisson, and Zero Inflated Negative Binomial regression models. When there is an excess of zeros in count data, zero inflated models are often used. Zero inflated models are most appropriate when we expect that some of these zeros are "structural zeros," in this case individuals who never consume alcohol, but some

of the zeros are also due to sampling methods, in this case individuals who sometimes consume alcohol and do not consume alcohol at other times. This is common in count outcomes of substance use (Atkins, Baldwin, Zheng, Gallop, & Neighbors, 2013). Negative binomial models are more appropriate for count data in which the data are over dispersed. This is demonstrated by variance higher than the mean, but can also be formally tested with over dispersion tests (Cameron & Trivedi, 1990). Additionally, model fit can be assessed with the Vuong Test (Vuong, 1989). The Vuong Test was used to compare over-dispersion and model fit for each model, and we selected the most appropriate model based on these tests.

The zero inflated models simultaneously perform two models to examine two aspects of the count outcome: 1) a count model to examine the count among non-excess zeros and 2) a logit model to examine the zero vs. any non-zero count. For the count model, the covariate is connected to the outcome via a log link and can be exponentiated to yield a Count Ratio (CR; also known as a Rate Ratio) for the proportional change in the count associated with a 1-unit increase in the covariate. Odds ratios for having a zero vs. a non-zero count were estimated using the logit portion of the model.

First we ran Poisson, Zero Inflated Poisson, and Zero Inflated Negative Binomial regression models assessing the main effect of sex differences and mindfulness, impulsivity, and sensation seeking on alcohol use. Next, we ran moderation analysis with Poisson, Zero Inflated Poisson, and Zero Inflated Negative Binomial regression models assessing the moderating effect of sex on the relationship between mindfulness, impulsivity, and sensation seeking and alcohol use. We then followed the same structure for premenstrual symptoms. First we looked at the main effect of premenstrual symptoms and mindfulness, impulsivity, and sensation seeking onto alcohol use, and then the moderation of the relationship between alcohol use and mindfulness, impulsivity, and sensation seeking

by premenstrual symptoms. We report all analyses for main effects, but only display results for significant interactions.

4.2 Main effect of Sex and Mindfulness, Impulsivity, and Sensation Seeking on Alcohol Use

Participant demographics are displayed for the outcome and covariate variables for each time point by sex in Table 1 (12 months n = 1,404, 18 months n = 1,303). The zero-inflated negative binomial model was the best fit for modeling the associations of sex, mindfulness, impulsivity and sensation seeking with Peak BAC, Typical BAC, Total Drinks per Week, the YAAPST, the RAPI Abuse/Dependence Subscale, and the RAPI Personal Consequences Subscale. The zero-inflated poisson glm was the best fit for modeling the associations of sex, mindfulness, impulsivity and sensation seeking with Days of Drinking, and the RAPI Social Consequences Subscale.

Alcohol Related Negative Consequences

Table 1. Descriptive Statistics and Mean Comparison of Covariates by Sex

		Female		**Male**	
	N = 1404	n = 876, 62%		n = 528, 38%	
		M	***SD***	***M***	***SD***
Mindfulness					
	CAMSR	31.748	6.051	33.276	5.678
Impulsivity					
	Impulsivity	2.245	1.986	2.397	1.968
	Sensation Seeking	5.792	3.156	6.080	3.244
Premens Sxs				--	--
	SPAF	21.935	10.809	--	--
		Female		**Male**	
18-Month	N = 1303	n = 841, 65%		n = 462,35%	
		M	*SD*	*M*	*SD*
Quantity					
	Typical BAC	6.456	7.982	5.542	7.613
	Peak BAC	9.505	9.931	8.569	9.931
Frequency					
	Drink Days	1.145	1.23	1.28	1.404
	Total Drinks Week	4.237	5.318	6.133	9.205
Neg Conseq					
	YAAPST	2.278	2.962	2.637	3.548

RAPI	**Abuse/Depend**	0.692	1.801	1.023	2.438
	Personal Conseq	0.602	1.469	0.966	2.006
	Social Conseq	0.488	1.000	0.634	1.097

The results from the negative binomial (Table 2) and poison (Table 3) models of the main effect of sex, mindfulness, impulsivity and sensation seeking on alcohol use revealed several significant main effects. In the count model there was a significant negative effect of sex on Total Drinks per Week, such that males report higher Total Drinks per week than females. However, there were no other significant sex differences in alcohol use.

In the count models, mindfulness was significantly negatively related to the YAAPST and the RAPI subscale of Personal Consequences. This suggests that as mindfulness increases by one unit the YAAPST decreases by a CR (calculated by exponentiating the log odds count of -0.043) of 0.958 and the RAPI subscale of Personal consequences decreases by a CR of 0.939. No other main effects of mindfulness were significant.

For impulsivity, the count models found positive relationships between impulsivity and the YAAPST (CR = 1.133) and the RAPI subscale of Abuse/Dependence (CR = 1.145). The zero inflated model suggests higher impulsivity is associated with higher odds for having a non-zero score for the RAPI subscale of Abuse/Dependence (OR = 0.952). Additionally, higher impulsivity was associated with higher odds for being female (OR = 1.789).

For sensation seeking the count models found positive relationships with Peak BAC, Typical BAC, Total Drinks per Week, and the YAAPST, such that a one unit increase in sensation seeking related to a increase in Peak BAC by an CR of 1.078, Typical BAC by a CR of 1.196, Total Drinks per Week by a CR of 1.198, and the YAAPST by a CR of 1.235. The zero inflated models also suggest an increase of alcohol use associated with sensation seeking for Peak BAC, Typical BAC, Days Drinking, Total Drinks per Week, the

YAAPST, and the RAPI subscales of Abuse/Dependence, Personal Consequences and Social Consequences. As sensation seeking increases the odds for having a zero vs. a non-zero count decreases for Peak BAC (OR calculated by exponentiating the logit estimate of -0.111 = 0.895), Typical BAC (OR = 0.891), Days Drinking (OR = 0.894), Total Drinks per Week (OR = 0.834), the YAAPST (OR = 0.810), and the RAPI subscales of Abuse/Dependence (OR = 0.650), Personal Consequences (OR = 0.710), and Social Consequences (OR = 0.786).

Table 2. Zero Inflated Negative Binomial Models of the main effect of Sex, Mindfulness, Impulsivity, and Sensation Seeking onto Alcohol Use

	Peak BAC				Typical BAC				Total Drinks Per Week				YAAPST				RAPI Abuse				RAPI Personal Consequences			
Mindfulness	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*
Count Model																								
Sex (Female)	-0.025	-0.224	0.174	0.804	0.156	-0.068	0.380	0.173	-0.382	-0.645	-0.119	0.004	-0.051	-0.306	0.205	0.697	-0.157	-0.631	0.317	0.516	-0.226	-0.642	0.191	0.288
CAMSR	-0.004	-0.020	0.013	0.674	-0.015	-0.035	0.004	0.123	-0.011	-0.033	0.011	0.329	-0.022	-0.043	0.000	0.047*	-0.013	-0.053	0.027	0.519	-0.063	-0.116	-0.009	0.021*
Zero Inflated																								
Sex (Female)	-0.133	-0.548	0.281	0.528	0.014	-0.412	0.440	0.949	-0.027	-0.467	0.412	0.903	-0.224	-0.734	0.287	0.391	-1.017	-3.664	1.631	0.452	0.112	-0.636	0.860	0.769
CAMSR	-0.020	-0.052	0.012	0.213	-0.026	-0.058	0.007	0.120	-0.002	-0.035	0.032	0.922	-0.006	-0.048	0.035	0.759	0.441	-0.031	0.913	0.067	-0.026	-0.120	0.068	0.584

	Peak BAC				Typical BAC				Total Drinks Per Week				YAAPST				RAPI Abuse				RAPI Personal Consequences			
Impulsivity	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*
Count Model																								
Sex (Female)	-0.023	-0.221	0.174	0.817	0.175	-0.047	0.398	0.123	-0.376	-0.637	-0.116	0.005*	0.009	-0.235	0.252	0.945	0.046	-0.427	0.519	0.848	-0.181	-0.621	0.258	0.418
Impulsivity	0.015	-0.035	0.065	0.558	0.038	-0.020	0.096	0.197	0.028	-0.038	0.093	0.407	0.125	0.062	0.187	<0.001*	0.135	0.018	0.251	0.023*	0.072	-0.038	0.181	0.199
Zero Inflated																								
Sex (Female)	-0.106	-0.517	0.306	0.614	0.051	-0.372	0.473	0.814	-0.019	-0.456	0.417	0.930	-0.205	-0.703	0.294	0.422	0.548	-1.695	2.791	0.632	0.144	-0.679	0.967	0.731
Impulsivity	0.038	-0.066	0.142	0.471	0.046	-0.060	0.152	0.399	-0.023	-0.135	0.089	0.690	0.103	-0.025	0.231	0.116	-0.126	-0.663	0.412	0.646	-0.062	-0.284	0.159	0.583

	Peak BAC				Typical BAC				Total Drinks Per Week				YAAPST				RAPI Abuse				RAPI Personal Consequences			
Sensation Seeking	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*	*Est*	*CI- 2.5%*	*97.5%*	*p*
Count Model																								
Sex (Female)	-0.032	-0.221	0.156	0.738	0.178	-0.041	0.397	0.110	-0.409	-0.656	-0.162	0.001*	0.012	-0.236	0.259	0.926	-0.193	-0.684	0.298	0.440	-0.259	-0.675	0.158	0.224
Sensation Seeking	0.075	0.045	0.105	<0.001*	0.056	0.020	0.092	0.002*	0.096	0.054	0.137	<0.001*	0.064	0.026	0.102	0.001*	0.018	-0.065	0.101	0.672	0.025	-0.046	0.097	0.489
Zero Inflated																								
Sex (Female)	-0.082	-0.498	0.334	0.700	0.074	-0.356	0.504	0.735	-0.017	-0.456	0.423	0.941	-0.159	-0.677	0.358	0.546	-0.447	-1.559	0.665	0.430	-0.041	-0.885	0.804	0.925
Sensation Seeking	-0.111	-0.173	-0.049	<0.001*	-0.115	-0.179	-0.052	<0.001*	-0.115	-0.181	-0.049	<0.001*	-0.028	-0.211	-0.050	0.001*	-0.431	-0.659	-0.202	<0.001*	-0.343	-0.525	-0.161	<0.001*

Table 3. Zero Inflated Poisson Models of the main effect of Sex, Mindfulness, Impulsivity, and Sensation Seeking onto Alcohol Use

	Days Drinking				RAPI Social Consequences			
Mindfulness	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model								
Sex (Female)	-0.094	-0.317	0.128	0.406	0.245	-0.089	0.579	0.151
CAMSR	-0.006	-0.024	0.013	0.553	0.004	-0.025	0.034	0.778
Zero Inflated								
Sex (Female)	0.001	-0.511	0.513	0.997	0.544	-0.017	1.105	0.058
CAMSR	-0.006	-0.047	0.035	0.781	0.044	-0.001	0.090	0.057
	Days Drinking				**RAPI Social Consequences**			
Impulsivity	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model								
Sex (Female)	-0.085	-0.307	0.136	0.451	0.307	-0.031	0.646	0.075
Impulsivity	0.002	-0.053	0.057	0.947	0.074	-0.012	0.160	0.090
Zero Inflated								
Sex (Female)	0.013	-0.497	0.523	0.960	0.581	0.007	1.155	0.047*
Impulsivity	-0.028	-0.157	0.102	0.677	-0.049	-0.188	0.090	0.490*
	Days Drinking				**RAPI Social Consequences**			
Sensation Seeking	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model								
Sex (Female)	-0.102	-0.324	0.1200	0.368	0.236	-0.095	0.567	0.162
Sensation Seeking	0.035	-0.002	0.072	0.066	0.014	-0.047	0.075	0.655
Zero Inflated								
Sex (Female)	0.005	-0.519	0.528	0.986	0.611	0.009	1.214	0.047
Sensation Seeking	-0.112	-0.193	-0.031	0.007*	-0.241	-0.343	-0.140	<0.001*

4.3 Moderation of Relationship between Alcohol Use and Impulsivity, Mindfulness, and Sensation Seeking by Sex

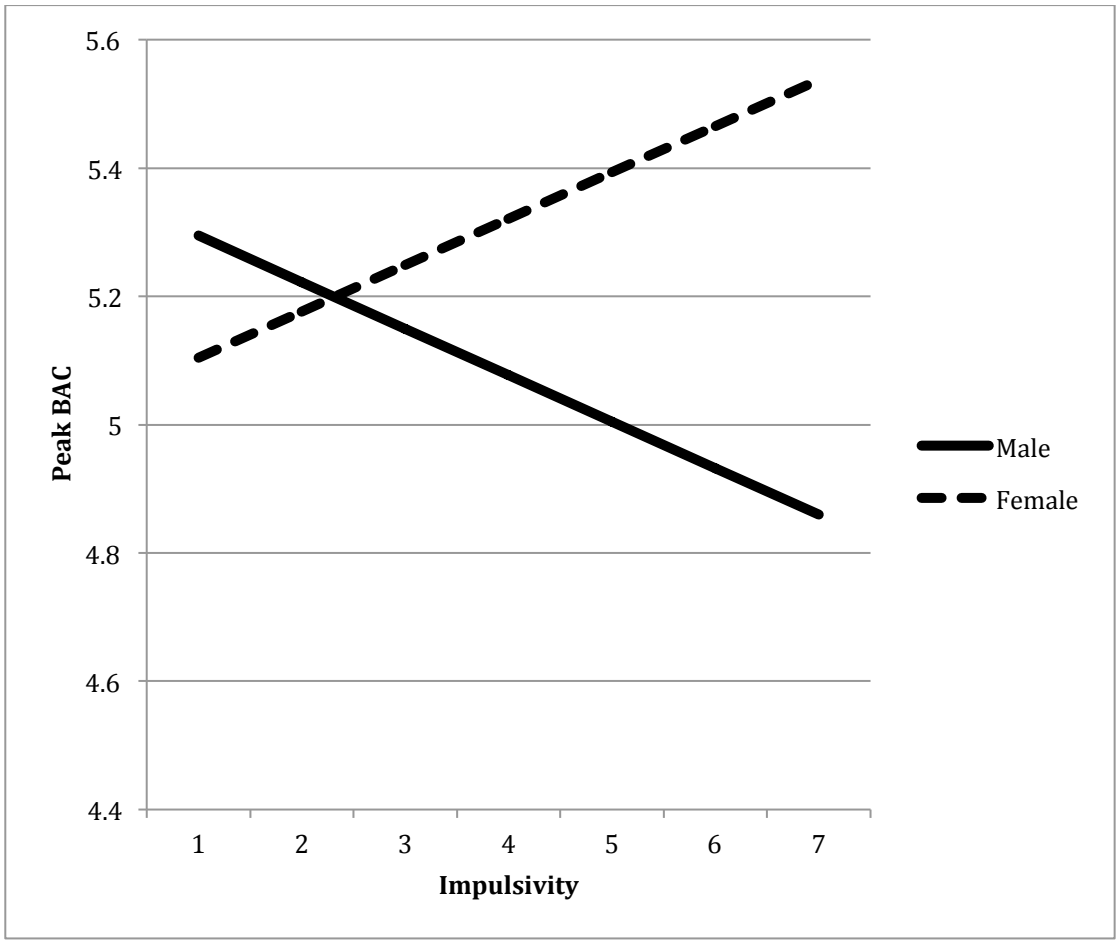
The zero inflated negative binomial model was the best fit for modeling the associations of Sex, mindfulness, impulsivity and sensation seeking on Typical BAC, Peak BAC, Total Drinks per Week, the YAAPST, the RAPI Abuse/Dependence and the RAPI Personal Consequences Subscales; whereas the zero-inflated Poisson model was the best fit for modeling Days of Drinking and the RAPI Social Consequences Subscales.

The only significant interaction was the moderation of the relationship between Peak BAC and impulsivity by sex (Table 4). As shown in Figure 1, sex moderated the relationship between impulsivity and Peak BAC such that higher impulsivity was more strongly related to Peak BAC for women than for men.

Table 4. Zero Inflated Negative Binomial Moderation of Peak BAC and Impulsivity by Sex

	Peak BAC			
Impulsivity	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model				
Sex (Female)	-0.335	-1.930	1.041	0.024*
Impulsivity	-0.072	-0.068	0.010	0.062
Sex * Impulsivity	0.145	-0.027	0.063	0.004*
Zero Inflated				
Sex (Female)	-0.047	-1.236	3.463	0.140
Impulsivity	-0.063	-0.062	0.058	0.465
Sex * Impulsivity	0.165	-0.105	0.038	0.134

Figure 1. Count Model- Moderation of the relationship between Peak BAC and Impulsivity by Sex



4.4 Main effect of Premenstrual Symptoms, Mindfulness and Impulsivity onto Alcohol Use

We modeled the relationship between premenstrual symptoms onto the alcohol outcomes with poisson, zero inflated poisson, and zero inflated negative binomial glm models. We used log likelihood, Vuong tests, and theoretical fit to select the best models for each outcome. The zero inflated negative binomial glm was the best fit for modeling the effects of premenstrual symptoms onto Peak BAC, Typical BAC, Total Drinks per Week, the YAAPST, the RAPI Abuse/Dependence Subscale, and the RAPI Personal Consequences Subscale. The zero inflated poisson glm was the best fit for modeling the

effects of premenstrual symptoms onto Days of Drinking, and the RAPI Social Consequences Subscale.

The results from the negative binomial (Table 4) and poison (Table 5) models of the main effect of premenstrual symptoms, mindfulness, impulsivity and sensation seeking on alcohol use revealed several significant main effects.

For premenstrual symptoms, the count model revealed a significant positive relationship between premenstrual symptoms and Typical BAC (CR = 1.011), and premenstrual symptoms and the RAPI subscale of Personal Consequences (CR = 1.017). Additionally, the zero-inflated models suggest that as premenstrual symptoms increase the odds of having a zero vs. a non-zero count decrease for Days Drinking (OR = 0.967).

The count models for mindfulness were all non-significant. However, the zero-inflated models suggest that as mindfulness increases the odds of having a zero vs. a non-zero count for the RAPI subscale of Social Consequences increase (OR = 1.006).

For impulsivity, the count models suggest that as impulsivity increases Peak BAC (CR = 1.055), Typical BAC (CR = 1.084), Total Drinks per Week (CR = 1.073), and the YAAPST (CR = 1.076) all increase as well. The zero inflated models suggest that as impulsivity increases the odds of having a zero vs. a non-zero count decrease for the RAPI subscale of Social Consequences (OR = 0.809).

With sensation seeking, the count models suggest that as sensation seeking increases Peak BAC (CR = 1.074), Typical BAC (CR = 1.059), Days Drinking (CR = 1.051), and Total Drinks per Week (CR =1.110) increase as well. The zero inflated models suggest that as sensation seeking increases the odds of having a zero vs. a non-zero count decrease for Peak BAC (OR = 0.894), Typical BAC (OR = 0.880), Days

Drinking (OR = 0.887), Total Drinks per Week (OR = 0.891), the YAAPST (OR = 0.876), and the RAPI subscales of Abuse/Dependence (OR = 0.689), Personal Consequences (OR = 0.784), and Social Consequences (OR = 0.787).

Table 4. Zero Inflated Negative Binomial Models of the Effects of Premenstrual Symptoms, Mindfulness, Impulsivity, and Sensation Seeking on Alcohol Use

	Peak BAC				Typical BAC				Total Drinks Per Week				YAAPST				RAPI Abuse/Dependence				RAPI Personal Co	
Mindfulness	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*
Count Model																						
PMS	0.005	-0.004	0.015	0.245	0.011	0.000	0.022	0.044*	0.001	-0.012	0.021	0.899	0.008	-0.003	0.019	0.155	0.013	-0.006	0.033	0.185	0.017	-0.004
CAMSR	0.002	-0.013	0.018	0.767	-0.013	-0.031	0.006	0.171	-0.003	-0.027	0.191	0.832	-0.013	-0.033	0.007	0.201	-0.019	-0.058	0.020	0.340	-0.009	-0.052
Zero Inflated																						
PMS	-0.007	-0.026	0.013	0.506	-0.009	-0.029	0.010	0.348	-0.022	-0.045	0.000	0.051	0.002	-0.021	0.025	0.859	0.029	-0.047	0.105	0.454	0.002	-0.035
CAMSR	-0.019	-0.052	0.015	0.283	-0.031	-0.066	0.004	0.080	0.001	-0.036	0.038	0.964	0.011	-0.030	0.053	0.589	0.080	-0.101	0.262	0.387	0.037	-0.042
	Peak BAC				**Typical BAC**				**Total Drinks Per Week**				**YAAPST**				**RAPI Abuse/Dependence**				**RAPI Personal Co**	
Impulsivity	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*
Count Model																						
PMS	0.003	-0.006	0.012	0.508	0.012	0.001	0.022	0.030*	-0.001	-0.014	0.012	0.882	0.007	-0.004	0.017	0.198	0.012	-0.008	0.032	0.226	0.017	-0.004
Impulsivity	0.054	0.008	0.100	0.021*	0.081	0.027	0.136	0.003*	0.070	0.005	0.134	0.035*	0.073	0.013	0.133	0.018*	0.071	-0.047	0.188	0.237	0.006	-0.105
Zero Inflated																						
PMS	-0.005	-0.025	0.014	0.594	-0.007	-0.027	0.013	0.487	-0.021	-0.043	0.058	0.068	0.001	-0.022	0.023	0.945	0.021	-0.044	0.086	0.530	0.003	-0.035
Impulsivity	0.021	-0.084	0.126	0.694	0.035	-0.072	0.141	0.523	-0.058	-0.174	0.043	0.325	0.015	-0.113	0.142	0.823	-0.006	-0.491	0.478	0.980	-0.269	-0.572
	Peak BAC				**Typical BAC**				**Total Drinks Per Week**				**YAAPST**				**RAPI Abuse/Dependence**				**RAPI Personal Co**	
Sensation Seeking	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*
Count Model																						
PMS	0.001	-0.008	0.010	0.835	0.011	0.001	0.022	0.039*	-0.004	-0.017	0.008	0.469	0.008	-0.003	0.019	0.163	0.008	-0.013	0.029	0.444	0.016	-0.004
Sensation Seeking	0.071	0.042	0.100	< 0.001*	0.057	0.020	0.093	0.003*	0.104	0.064	0.145	< 0.001*	0.036	-0.004	0.075	0.077	-0.004	-0.105	0.096	0.931	0.025	-0.050
Zero Inflated																						
PMS	-0.002	-0.022	0.018	0.848	-0.003	-0.023	0.017	0.792	-0.020	-0.042	0.003	0.083	0.006	-0.018	0.030	0.603	-0.006	-0.065	0.053	0.839	0.007	-0.028
Sensation Seeking	-0.112	-0.177	-0.047	0.001*	-0.128	-0.195	-0.061	< 0.001*	-0.115	-0.186	-0.044	0.002*	-0.132	-0.216	-0.047	0.002*	-0.373	-0.700	-0.046	0.025*	-0.243	-0.381

Table 5. Zero Inflated Poisson Models of the Effects of Premenstrual Symptoms, Mindfulness, Impulsivity, and Sensation Seeking on Alcohol Use

	Days Drinking				RAPI Social Consequences			
Mindfulness	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model								
PMS	-0.008	-0.020	0.003	0.166	0.019	0.003	0.034	0.021*
CAMSR	-0.005	-0.025	0.016	0.639	0.022	-0.009	0.053	0.170
Zero Inflated								
PMS	-0.035	-0.067	-0.003	0.031*	-0.003	-0.028	0.022	0.811
CAMSR	-0.005	-0.050	0.039	0.820	0.054	0.006	0.102	0.029*
	Days Drinking				**RAPI Social Consequences**			
Impulsivity	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model								
PMS	-0.009	-0.020	0.091	0.142	0.016	0.001	0.031	0.038*
Impulsivity	0.038	-0.014	0.151	0.153	-0.042	-0.127	0.043	0.327
Zero Inflated								
PMS	-0.033	-0.066	-0.001	0.044*	-0.004	-0.029	0.020	0.727
Impulsivity	-0.053	-0.190	0.084	0.446	-0.212	-0.359	-0.065	0.005*
	Days Drinking				**RAPI Social Consequences**			
Sensation Seeking	*Estimate*	*CI- 2.5%*	*97.5%*	*p*	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model								
PMS	-0.010	-0.021	0.002	0.102	0.015	-0.001	0.030	0.065
Sensation Seeking	0.050	0.013	0.088	0.008*	0.006	-0.062	0.074	0.868
Zero Inflated								
PMS	-0.034	-0.070	0.001	0.060	-0.002	-0.029	0.024	0.861
Sensation Seeking	-0.120	-0.211	-0.028	0.010*	-0.239	-0.343	-0.135	< 0.001*

4.6 Moderation of Relationship between Alcohol Use and Mindfulness, Impulsivity, and Sensation Seeking by Premenstrual Symptoms

We modeled the relationship between alcohol outcomes and mindfulness, impulsivity, and sensation seeking as moderated by premenstrual symptoms with Poisson, zero inflated poisson, and zero inflated negative binomial glm models. We used Log likelihood, Vuong tests, and theoretical fit to select the best models for each outcome. The zero inflated negative binomial glm was the best fit for modeling the

effects of premenstrual symptoms onto Peak BAC, Typical BAC, Total Drinks per Week, the YAAPST, the RAPI Abuse/Dependence Subscale, the RAPI Personal Consequences Subscale, and the RAPI Social Consequences Subscale. The zero inflated poisson glm was the best fit for modeling the effects of premenstrual symptoms onto Days of Drinking. The results from the zero inflated negative binomial models are in Table 6. The only significant interactions were in the zero inflated model between premenstrual symptoms, mindfulness, and Peak BAC, and the count model between premenstrual symptoms, impulsivity, and the RAPI subscale of Personal Consequences.

As shown in Figure 2, premenstrual symptoms moderated the relationship between mindfulness and Peak BAC such that higher mindfulness was related to higher Peak BAC, especially when premenstrual symptoms were high. As demonstrated in Figure 3, premenstrual symptoms moderated the relationship between impulsivity and the RAPI subscale of Personal Consequences such that higher impulsivity was related to higher Personal Consequences, especially premenstrual symptoms were high.

Table 6. Zero Inflated Negative Binomial Models of the Effects of Mindfulness and Sensation Seeking onto Alcohol Moderated by Premenstrual Symptoms

	Peak BAC			
Mindfulness	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model				
PMS	-0.006	-0.055	0.043	0.816
CAMSR	-0.006	-0.045	0.033	0.764
PMS*CAMSR	0.004	-0.012	0.020	0.648
Zero Inflated				
PMS	-0.126	-0.230	-0.021	0.018*
CAMSR	-0.104	-0.185	-0.024	0.011*
PMS*CAMSR	0.039	0.006	0.072	0.021*
	RAPI Personal Consequences			

Impulsivity	*Estimate*	*CI- 2.5%*	*97.5%*	*p*
Count Model				
PMS	-0.023	-0.057	0.012	0.2
Impulsivity	-0.355	-0.638	-0.071	0.014*
PMS * Imp	0.145	0.038	0.252	0.008*
Zero Inflated				
PMS	-0.044	-0.117	0.029	0.234
Impulsivity	-0.718	-1.512	0.076	0.076
PMS * Imp	0.185	-0.075	0.445	0.163

Figure 2. Zero Inflated Model- Moderation of the relationship between Peak BAC and Mindfulness by Premenstrual Symptoms

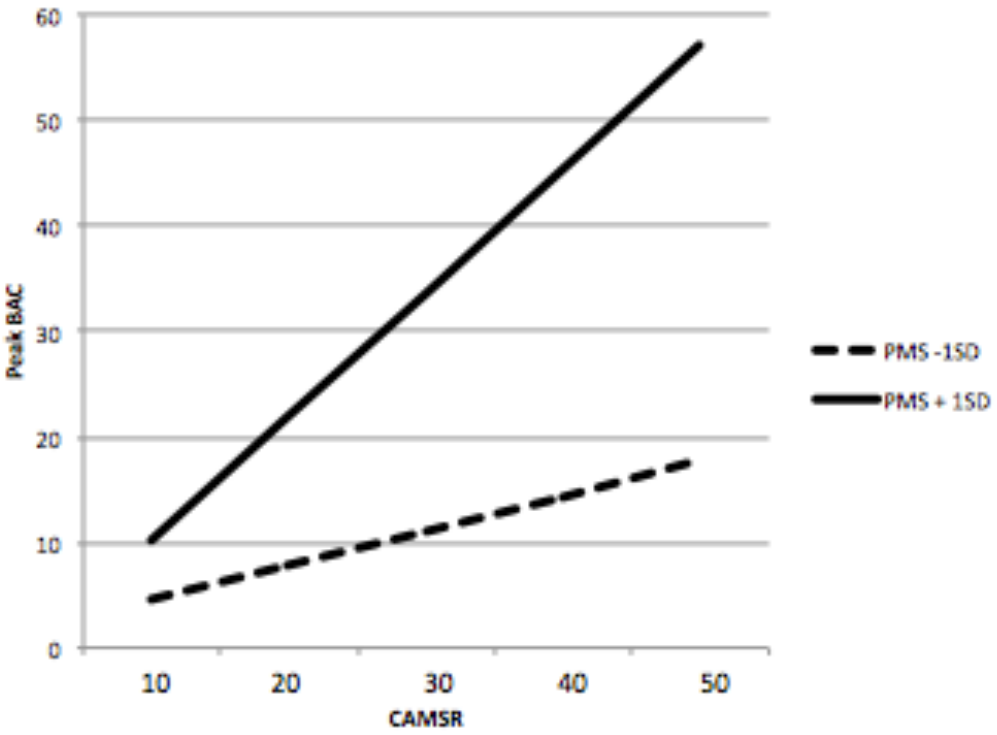
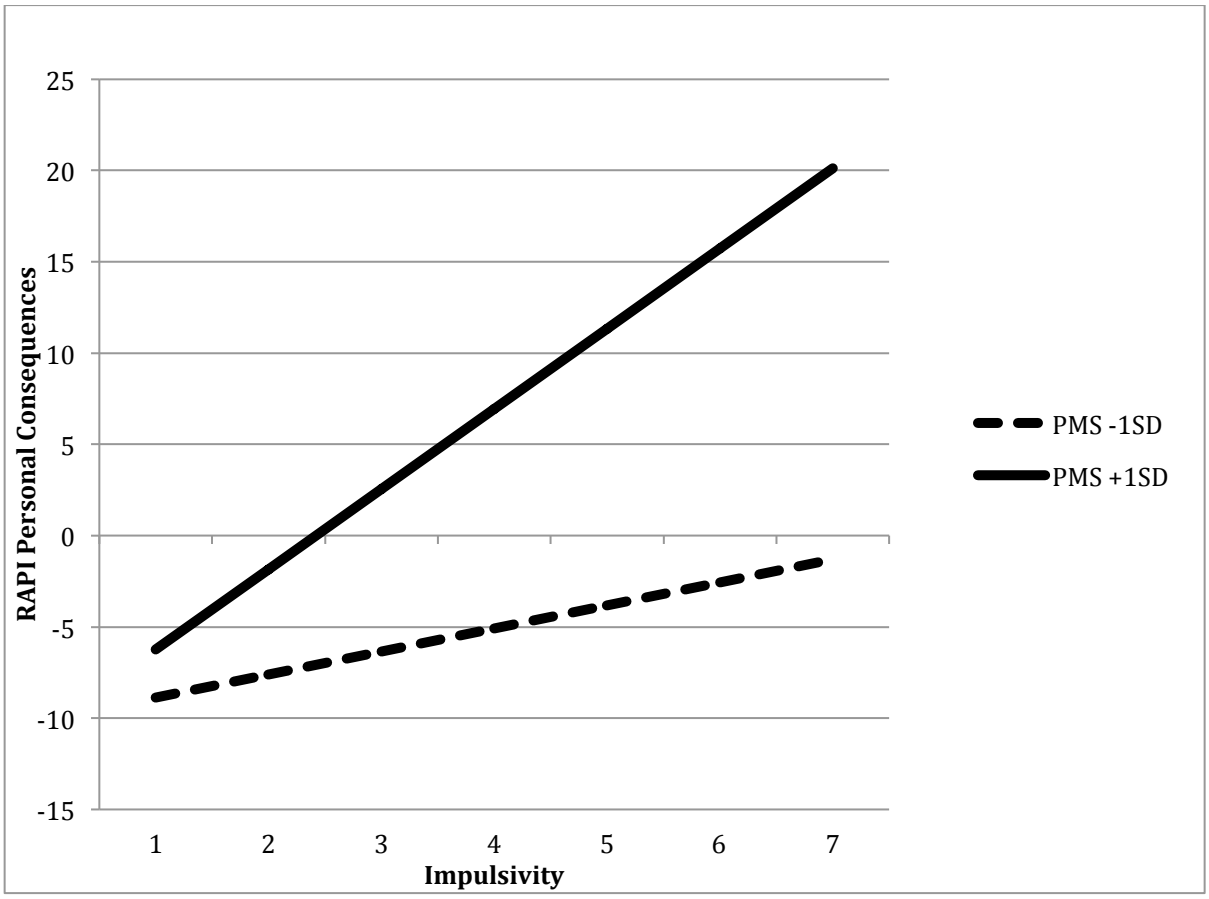


Figure 3. Count Model- Moderation of the relationship between RAPI Personal Consequences and Impulsivity by Premenstrual Symptoms



5. Discussion

The present study looks at the relationship between sex, premenstrual symptoms, impulsivity, sensation seeking, and mindfulness predicting alcohol related outcomes six months later. First, we were interested in sex differences in alcohol use. Except for Total Drinks per Week (higher for men), there were no sex differences in alcohol related outcomes. We did find that sex significantly moderated the relationship between impulsivity and Peak BAC, which we discuss in more detail below. In combination, this suggests that there may not be substantive differences in the quantity and frequency of alcohol use, or negative outcomes of alcohol use by sex. This supports recent epidemiological evidence suggesting that the sex gap in alcohol use in younger cohorts is closing (Slade et al., 2016). Additionally, save for the sex differences in impulsivity and

Peak BAC, there is not much evidence to suggest that the mechanisms of alcohol use differ substantively on average by sex. However, looking specifically within women, premenstrual symptoms have at least some influence on alcohol use.

To look at the relationship between premenstrual symptoms and alcohol use, we restricted our analyses to the sub-sample of women. We found that premenstrual symptoms were related to increases in some of our measures of quantity and frequency of alcohol use and alcohol related negative consequences as measured 6-months later. While this was true for only some of our measures, it does suggest that women may be self-medicating against premenstrual symptoms with alcohol use. However, as we did not measure alcohol use during the time period when women experience premenstrual symptoms, we cannot be confident that alcohol use is directly related to their premenstrual symptoms. As such, there may be another factor contributing to both increased premenstrual symptoms and increased alcohol use, which future research should address.

When we probed for interactions we found that premenstrual symptoms moderated the relationship between Peak BAC and mindfulness, and the relationship between impulsivity and the RAPI subscale of Personal Consequences, such that higher mindfulness and impulsivity were more strongly related to higher alcohol use when premenstrual symptoms were higher. This suggests that premenstrual symptoms may amplify alcohol use and negative consequences such that impulsivity has a more negative impact, and even dispositional mindfulness is not protective against alcohol use. In fact, dispositional mindfulness can perhaps be harmful for women with higher premenstrual symptoms when considering alcohol use. Prior research found that higher dispositional

mindfulness was related to lower premenstrual symptoms (Lustyk et al., 2011), so it may be that for women where this is not the case mindfulness is functioning in a different way. If mindfulness typically lowers premenstrual symptoms, perhaps for women where this does not happen the awareness of their premenstrual symptoms can be so great that they self medicate with alcohol. The finding that high impulsivity and high premenstrual symptoms are related to alcohol related negative consequences is as expected. This suggests that women who experience more premenstrual symptoms may act rashly in ways that can cause negative consequences when under the influence of alcohol use. In combination, these results suggest that premenstrual symptoms are a risk factor for alcohol use and alcohol related negative consequences. This is in line with other research finds that alcohol consumption is related to premenstrual symptoms (Gold et al., 2007).

We also looked at the main effect of mindfulness, impulsivity, and sensation seeking on alcohol use. Results were in line with our hypotheses. First, mindfulness was associated with lower alcohol related negative consequences in the full sample, and we when we looked just at women. It is of note that mindfulness was not related to the reported quantity and frequency of alcohol consumed. This suggests that dispositional mindfulness, as we measured here, may not be important for levels of alcohol use, but help reduce the negative effects of alcohol use. The exact mechanisms of this are difficult to say given our that our measure of mindfulness is global and lacks more nuanced subscales, but it may be that dispositional mindfulness provides a space for non-judgment such that mindful young adults are able to move on from any mistakes that they make under the influence of alcohol use. Or, conversely, mindfulness may introduce a space between stimulus and response under the influence of alcohol use such that young adults

high in dispositional mindfulness make fewer mistakes under the influence of alcohol. Further research is needed to identify by what mechanisms dispositional mindfulness may protect young adults from the negative related consequences of alcohol use.

Next, impulsivity was related to higher alcohol related negative consequences in the full sample, and higher alcohol use and alcohol related consequences when we looked just at women. Given consistent evidence that alcohol related negative consequences are predicted by impulsivity, these results were as expected, and in line with prior research (Magid et al., 2007). Additionally, higher impulsivity was related to being female. As mentioned earlier, further interaction probing suggested that sex moderated the relationship between impulsivity and Peak BAC such that high impulsivity was more strongly related to higher Peak BAC for women. Given that there was only one significant interaction among all our tests, there is little evidence to suggest a pattern of differences in alcohol use mechanisms by sex. However, this particular finding supports other research that suggests that impulsivity (or poor response inhibition) is higher for heavy drinking young women when compared to men or women who do not drink heavily (Nederkoorn, Baltus, Guerrieri, & Wiers, 2009; Townshend & Duka, 2005). Several hypotheses can explain this sex difference. It may be that for men, other risk factors such as social environment are more important for alcohol use than in women. Future research should continue to look at sex differences in risk factors for alcohol use, as these may be important to target in prevention efforts or treatment programs for alcohol use.

Finally, sensation seeking was related to increases in all types of alcohol use and negative consequences in the full sample and among the female subsample. Some

research has found that sensation seeking is more likely to be related to alcohol use than alcohol related negative consequences (Magid et al., 2007), but we found that this extended to negative consequences as well. Neither sex nor premenstrual symptoms moderated the relationship between sensation seeking and alcohol related outcomes. This suggests that sensation seeking is a robust predictor of alcohol use for all regardless of sex, or premenstrual symptomology.

The present study presents some limitations. First, we asked women to recall premenstrual symptoms for their last menstrual cycle. Daily diary reporting of premenstrual symptoms is more accurate than retrospective self-report, and the associations between premenstrual symptoms and alcohol related outcomes should be interpreted with caution. In particular, most research looking at the relationship between premenstrual symptoms and alcohol use have been cross-sectional, and it is difficult to say if alcohol consumption causes premenstrual symptoms or vise-versa. While the present study looked at baseline premenstrual symptoms as associated with prospective alcohol use 6-months later, we do not have information on whether this alcohol consumption occurred during the premenstrual period. Indeed, some third factor (e.g., anxiety) could be responsible for the association between higher premenstrual symptoms and higher alcohol use. Future research should look to see if premenstrual symptoms are directly related to alcohol use at the time of consumption.

In summary, alcohol use and alcohol related negative consequences are elevated in adolescents, making this an important age at which to intervene for prevention. Prior research has suggested that sex, premenstrual symptoms, and individual psychological factors might influence alcohol use. The present study suggests that sex is not a strong

contributor to alcohol use and alcohol related negative consequences in young adults. However, for women premenstrual symptoms were a contributor to alcohol use outcomes. In light of recent epidemiological evidence that the sex gap in alcohol use is closing, this study suggests that younger cohorts of men and women may have similar mechanisms of alcohol use and alcohol use prevention, however premenstrual symptoms are a unique risk factor for young women. Given a significant sex bias against women in alcohol use literature, future research should continue to include sex as a variable of concern, as there is still a dearth of relevant information on which to draw.

5. General Conclusions

5.1 Alcohol Consumption and Menstrual Cycle Phase

The present thesis presents three papers investigating dispositional factors that predict alcohol consumption in young adult women. The primary aim of the present dissertation is to increase our understanding of alcohol consumption in young adult women. Thus, we investigated the effects of menstrual cycle phase, sex, and premenstrual symptoms on alcohol use. The review paper (Carroll et al., 2015), a systematic review of exsisiting literature on menstrual cycle phase and alcohol use, finds mixed evidence on the relationship between menstrual cycle and alcohol consumption. The What Women Want study (Carroll et al., Under Review), a repeated-measure psychophysiological labatory investigation of the relationship between menstrual cycle, impulsivity, cognitive flexibility, and attention control, finds only a few significant relationships between menstrual cycle phase, impulsivity, and CVC. The ATLAS paper (Carroll & Larimer, Under Review), a large scale online-survey investigating sex differences in alcohol consumption and the influence of sex and premenstrual symptoms on alcohol consumption and consequences prospectively, finds little evidence to support sex differences in alcohol consumption, but finds that for women with higher premesntrual symptoms alcohol use and alcohol related negative consequences are higher. In combination these results suggest that alcohol consumption and mechanisms for alcohol consumption within the conceptual model presented here do not vary substantively by sex or menstrual cycle phase, excpet for when there are menstrual cycle-related complications as in premenstrual symptom severity. When considering dispositional

factors that contribute to alcohol consumption in women in the general population, it appears that similar factors may influence alcohol consumption as we see in men.

5.2 Alcohol Use and the Behavioral Model of Choice

Impulsivity

In addition to the main effect of sex, menstrual cycle phase, and premenstrual symtpoms on alcohol use, we investigated how these sex related factors moderated the relationship between well established psychological risk factors and alcohol consumption. Prior research has been consistent in associating higher levels of impulsivity with higher levels of alcohol consumption, and our aim was to test this in relationship for women and considering menstrual cycle phase and premenstrual symptoms. Given the lack of alcohol consumption in the What Women Want study, only the ATLAS project looks directly at the prospective relationship between impulsivity and alcohol consumption (Carroll & Larimer, Under Review). Results of the ATLAS project indicated that impulsivity was positively related to alcohol consumption and alcohol-related negative consequences, and sex was not a substantive contributor to this relationship (Carroll et al., Under Review). The only significant interaction between sex and premenstrual symptoms and alcohol use was with mindfulness onto Peak BAC. The positive relationship between alcohol consumption and impulsivity is highly consistent with prior research (e.g. Magid et al., 2007). This also suggests that sex and/or premenstrual symptoms do not affect the relationship between impulsivity and alcohol use.

Additionally, we explored the relationship between impulsivity and attention control. While the What Women Want study was unable to assess the direct relationship

between menstrual cycle phase and alcohol use (Carroll et al., Under Review), we were able to look at the relationship between menstrual cycle phase, impulsivity and attention control. Lower levels of negative urgency, premeditation, perseverance, and sensation seeking were associated with higher levels of attention control, whereas higher levels of positive urgency and delay discounting were associated with higher levels of attention control. We originally hypothesized that all factors of impulsivity would be negatively related to mindfulness. However, looking at recent, and more nuanced, investigations into impulsivity and mindfulness and their relationship, it fits within an burgeoning area of research to suggest that some factors of mindfulness are negatively associated with impulsivity, whereas others are positively related to impulsivity (Murphy & MacKillop, 2012). This has implications for how we might think about dispositional mindfulness as a predictor for substance use, and suggests that some factors of mindfulness might be more helpful in some populations than others. With young women in particular, understanding the mechanisms for alcohol consumption and how mindfulness and impulsivity contribute to this will be informative for understanding the utility of mindfulness treatment for alcohol consumption.

Cardiac Vagal Control

The present thesis looked at Cardiac Vagal Control (CVC) as a measure of the executive system that may provide some protection against alcohol use. We were particularly interested in the relationship between CVC and alcohol use by menstrual cycle phase. Again, due to a lack of alcohol consumption in the What Women Want study (Carroll et al., Under Review), we were not able to test the direct relationship between CVC and amount of alcohol consumption. However, we did test the relationship

between menstrual cycle phase and CVC, and the effect of attention control on this relationship. The results from this are discussed in the discussion of the What Women Want Study (Carroll et al., Under Review). In brief, there was no relationship with menstrual cycle phase, but Respiratory Sinus Arrhythmia (RSA) was negatively related to the Mindful Attention and Awareness Scale measure of mindfulness and the Five Factor Mindfulness Questionnaire subscale of acting with awareness factors of mindfulness. While we expected a positive relationship such that higher levels of mindfulness were associated with higher RSA, our study is one of the few studies that investigates the relationship between trait mindfulness and RSA. Our findings align with the existing literature that looks at CVC and dispositional mindfulness (Garland et al., 2010). This suggests that trait mindfulness might have a different relationship with stress engagement than mindfulness evinced via treatment programs.

5.3 Conclusions

While it is difficult to argue the null (menstrual cycle has no effect on alcohol use) in each of the studies included in the present dissertation, the general trend suggests that menstrual cycle phase is not a robust factor influencing alcohol consumption. Similar risk factors, like impulsivity, that are important for alcohol use in men appear to be important for alcohol use in women, regardless of menstrual cycle phase. These findings are important because research on a variety of topics, including alcohol use, has been biased against including women in large part due to menstrual cycle (Holdcroft, 2007). Historically, women have been exlcuded from clinical trials due to hormone fluctation related to menstrual cycle, risk of pregnancy, or contraceptive use. This stigma has real effects on our understanding of many health factors in women including alcohol

consumption. It is important to understand the mechanisms for alcohol use by sex, race/ethnicity, and other undresearched factors in order to ethically treat alcohol use disorders and create appropriate prevention programs. The trend found in the present study suggests that women should not be excluded from any alcohol consumption research based on menstrual cycle.

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