PSYCHOPATHY AND ALCOHOL USE: THE POTENTIAL ROLE OF CIRCADIAN ENTRAINMENT

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ABSTRACT

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Previous literature has indicated that there is a fairly strong correlation between psychopathy and alcohol consumption , as well as a bidirectional relationship between circadian entrainment and alcohol consumption. Using self-reported data regarding sleep patterns from a group of undergraduate students, this study investigated the potential moderating and mediating associations of circadian rhythm entrainment on the relationship between psychopathic behavior and alcohol use . It was hypothesized that the relationship between psychopathy and alcohol use would become stronger with weaker circadian entrainment. It is also predicted that circadian entrainment will have a mediating role in the psychopathy-alcohol use relationship in that the relationship will no longer be statistically significant when circadian entrainment is controlled for. This study will use regression analyses to examine the association between circadian rhythms entrainment and psychopathy on alcohol consumption and analyze interaction effects of psychopathy/circadian rhythms as part of mediation/moderation test. Results will be interpreted from a biopsychosocial perspective and indicate that circadian entrainment does not serve as a moderator or mediator in the relationship between psychopathy and alcohol use.

KEY WORDS: Circadian rhythms, Alcohol use, Psychopathy, Sleep.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

CHAPTER I

Introduction

Sleep has many far-reaching impacts, including physiological, psychological, cognitive, and social functions in humans (Hasler & Pedersen, 2020; Hastings et al., 2007; McMakin & Alfano, 2015; Mears et al., 2020; Provencher et al., 2020). For example, a lack of sleep has been associated with various mood and personality disorders (McMakin & Alfano, 2015; Provencher et al., 2020) as well as involvement in the development of major systemic illnesses (Hastings et al., 2007). While not the only diurnal cycle maintained by circadian entrainment[1] to exogenous stimuli, sleep patterning is one of the more well studied indicators of circadian rhythms. The chronobiology literature is extensive, and the mechanisms involved in entrainment are relatively well understood at the molecular and structural level. In addition, the relationship between alcohol consumption and circadian entrainment has been heavily studied in the field of chronobiology and generally finds that alterations in circadian functioning associate with alcohol consumption in a bidirectional manner (Meyrel et al., 2020, Rosenwasser & Fixaris, 2013; Spanagel et al., 2005).

This body of knowledge is now being integrated into the criminological literature; recent studies have investigated the role sleep plays in antisocial behavior (ASB) and personality characteristics such as the Dark Triad and psychopathy (Akram et al., 2019; Clinkinbeard et al., 2011; Drinkwater et al., 2020; Huýnh et al., 2016; Mears et al., 2020; Yang et al., 2019).

[1] Entrainment, according to Golombek and Rosentstein (2010), refers to the ability of exogenous rhythmicity to coordinate endogenous cycles, i.e., synchronization. Hofstra and de Weerd (2007) refer to entrainment as daily adjustments to external cues.

Taken together, sleep patterns have been found to be associated with both psychopathy and alcohol consumption. In turn, there is a large body of research that links psychopathy and increased alcohol consumption (Gillen et al., 2016; LaLiberte & Grekin, 2015; Swogger et al., 2017; Sylvers et al., 2011). This thesis will discuss the known mechanisms of circadian entrainment specifically as it relates to alcohol consumption and mood/behavior, and the potential role in understanding the etiology of the psychopathy-alcohol use relationship.

Circadian rhythms are diurnal cycles with a roughly 24-hour period (Bedrosian & Nelson, 2017; Hastings et al., 2007; Herzog, 2007; Yoshimura & Ebihara, 1998). Circadian rhythms are responsible for coordinating biological functions such as "sleep-wake behavior, hormone secretion, cellular function and gene expression" (Bedrosian & Nelson, 2017, p. 1). Both intrinsic and extrinsic factors influence the synchronization of daily rhythms; the most notable extrinsic factor being environmental lighting cues (Çalıyurt, 2017; Golombek & Rosenstein, 2010; Hofstra & de Weerd, 2007; Schmidt et al.,2011). A specific subset of retinal ganglion cells, known as intrinsically photosensitive retinal ganglion cells (ipRGCs), produce the novel photopigment melanopsin and are responsible for transmitting environmental lighting cues to the circadian pacemaker (Schmidt et al., 2011). The non-image forming information from the ipRGCs are projected to the suprachiasmatic nucleus of the hypothalamus (SCN) which houses the circadian clock and coordinates circadian-influenced functions (Schmidt et al., 2011). Entrainment to a 24-hour rhythmicity based on lighting cues is important for maintenance of physical and mental health; poor entrainment associates with certain "psychiatric and behavioral disorders", among other health risks (Bedrosian & Nelson, 2017, p.1).

Circadian rhythm disruption is also thought to have implications on mood disorders (Bedrosian & Nelson, 2017). Many mood disorders, such as anxiety, depression, and bipolar disorder are characterized by sleep disruption (Bedrosian & Nelson, 2017; Herzog, 2007). The limbic brain regions, monoamine neurotransmitters, and the hypothalamic-pituitary-adrenal (HPA) axis are thought to be under circadian influence (Bedrosian & Nelson, 2017) and have been implicated in several mood/mental disorders (Malhi et al., 2015; Shao & Zhu, 2020; Whalley et al., 2015; Zaki et al., 2018). The role of mood and several biomarkers for certain behaviors, such as ASB, has received empirical attention in criminology in recent years (Cooke et al., 2020; Figueiredo et al., 2020; Johnson et al., 2013; Kimonis et al., 2016; Loomans et al., 2016; Susman et al., 2017).

Another health risk of poor circadian entrainment is its association with problematic alcohol consumption. Both animal model studies and human studies have shown that poor synchronization relates to alterations in alcohol consumption (Hasler & Pedersen, 2020; Meyrel et al., 2020; Rosenwasser & Fixaris, 2013; Rosenwasser et al., 2020; Sinclair & Geller, 1972). Early animal model studies have shown that lighting condition influences drinking behavior in different species of rats; specifically, albino rats housed in constant light or constant dark showed increased alcohol drinking behaviors in free-choice scenarios (Sinclair & Geller, 1972). These early studies, however, were limited in their approach to understanding this relationship and more recent studies have attempted to address these limitations. In contrast to Sinclair and Geller (1972), Rosenwasser and colleagues (2020) used a more sophisticated methodological approach to indicate that mice housed in constant light or constant dark display reduced ethanol

consumption in free-choice scenarios. Becker et al. (2011) have indicated that, particularly for non-dependent animal models, environmental stressors may either increase or decrease ethanol consumption, depending on a wide range of factors. Therefore, empirical evidence supports a complex relationship between alcohol intake and environmental conditions, including the daily light-dark cycle (Becker et al., 2011; Rosenwasser et al., 2020; Sinclair & Geller, 1972). Several studies have indicated that increased alcohol consumption can also influence the ability to synchronize to a daily light-dark cycle (for review see Meyrel et al., 2020), indicating a bidirectional relationship between alcohol drinking and circadian entrainment (Spanagel et al., 2005).

In addition to the established relationships between alcohol consumption and circadian entrainment, several studies have indicated a robust association between alcohol consumption and the presence of psychopathic traits (LaLiberte & Grekin, 2015; Kramer et al., 2017). Specifically, the link between Factor 2 psychopathy and alcohol drinking is well established (LaLiberte & Grekin, 2015). Impulsivity (Kramer et al., 2017), behavioral activation, and positive alcohol expectancies (LaLiberte & Grekin, 2015) have been proposed as pathways for this observed relationship. LaLiberte and Grekin (2015) propose an increased sensitivity to alcohol coupled with a heightened reward responsiveness may lead to increased alcohol consumption in individuals high in psychopathy. In agreement, Kramer and colleagues (2017) state that poor behavioral control is responsible for the related alcohol pathology in secondary psychopathy. Kramer et al. (2017) further found that in individuals with diminished protective behavioral strategies (PBS), alcohol consumption increased and Factor 1 psychopathy

traits were more robust. PBS, in turn, was found to moderate the alcohol consumption – psychopathy relationship (Kramer et al., 2017).

Despite the dense chronobiological literature in relation to alcohol consumption and mood disorders, the literature regarding circadian rhythm alteration as a potential criminogenic factor is sparse. There are, however, a few studies that have indicated that sleep patterns potentially play an important role in various etiologies of criminal and antisocial behaviors (Akram et al., 2019; Clinkinbeard et al., 2011; Drinkwater et al., 2020; Huýnh et al., 2016; Mears et al., 2020; Yang et al., 2019). Instances of both too little sleep (Clinkenbeard et al., 2011; Mears et al., 2020) and too much sleep (Mears et al., 2020) have been associated with various forms of ASB. Not only has amount of sleep been found to impact ASB, but it has also been shown that individuals that display Dark Triad traits also display a preference for "eveningness" (Akram et al., 2019) and experience various sleep issues (Drinkwater et al., 2020; Yang et al., 2019).

Given what is known about these individual phenomena, it is possible that circadian rhythms play a mediating and/or moderating role in the association observed between psychopathy and alcohol consumption. In an effort to answer this question, this thesis tested several hypotheses. Specifically, it was predicted that the relationship between psychopathy and alcohol use would become stronger with weaker circadian entrainment. Further, circadian entrainment may have a mediating role in the psychopathy – alcohol consumption relationship in that the relationship will no longer be significant when circadian entrainment is controlled for. This thesis also predicted that circadian entrainment would mediate and/or moderate each of the three factors of psychopathy (egocentric, callousness, and antisocial) as they relate to alcohol use. These

hypotheses were tested using a sample of undergraduate students that participated in a self-administered survey and a lab measures protocol.

CHAPTER II

Literature Review

This thesis will review the known mechanisms of circadian rhythms and its resulting effects on behavior particularly as it relates to psychopathic traits and alcohol drinking behavior. A brief review of the structural and functional areas of the brain responsible for circadian rhythms will be provided, in addition to animal and human studies investigating the role circadian rhythms play in alcohol consumption. Additionally, the role of circadian rhythms in modulating daily cortisol cycles (often studied in biosocial criminology for its relationship to antisocial behavior) will be discussed in relation to psychopathy. The role of psychopathic tendencies in the development and maintenance of alcohol consumption will be reviewed. Finally, the potentially mediating and/or moderating role of circadian rhythms in the association between psychopathy and alcohol intake.

Circadian Rhythms

Circadian rhythms are diurnal cycles with a roughly 24-hour period that influence many mood centers of the brain, such as the hypothalamus, other limbic system structures, and the hypothalamic-pituitary-adrenal axis (Bedrosian & Nelson, 2017; Herzog, 2007). This highly accurate circadian clock is influenced by both internal and external stimuli (Golombek & Rosenstein, 2010; Hastings et al., 2007; Schmidt et al., 2011), most notably lighting conditions (Çalıyurt, 2017; Golombek & Rosenstein, 2010; Hofstra & de Weerd, 2007; Schmidt et al., 2011). Photic sensitivity has been defined as "the intensity required to induce a half-maximum response" (Yoshimura & Ebihara, 1998, p. 189) and has been used as a measure of circadian photosensitivity (Yoshimura &

Ebihara, 1998). Photosensitivity plays a major role in circadian synchronization to environmental lighting cues across various domains of life (Herzog, 2007). Though the exact mechanisms of circadian photosensitivity vary across species, modes of circadian entrainment to external stimuli are relatively conserved among mammals (Herzog, 2007; Golombek & Rosenstein, 2010), supporting the use of animal models for our understanding of circadian entrainment (Rosenwasser & Fixaris, 2013).

The visual system is a complex network of retinal cells and optic centers of the brain comprising image-forming and non-image forming visual processes (Schmidt et al., 2011). Originally, visual system involvement in circadian entrainment was thought to rely strictly on the relay of environmental lighting information received by rods and cones (Schmidt et al., 2011). However, several recent studies have demonstrated that circadian entrainment is not fully dependent on such photoreceptors (Paul et al., 2009; Schmidt et al., 2011). Despite an inability to visually perceive light cues, genetically modified mice and some blind humans with severely degenerated rods and cones nevertheless display circadian entrainment and other circadian responses to light (Schmidt et al., 2011). In support, previous studies indicated that animals with depleted rods and cones still showed circadian responses to light (Golombek & Rosenstein, 2010).

In the absence of rods and cones, circadian entrainment is mediated by a small subset of retinal ganglion cells referred to as intrinsically photosensitive retinal ganglion cells (ipRGCs; Bedrosian & Nelson, 2017; Hankins et al., 2007; Schmidt et al., 2011). In normal, intact animals, both rod and cone photoreceptors and ipRGCs contribute to circadian entrainment. ipRGCs contain the novel photopigment, melanopsin, which is largely responsible for entraining to light/dark cycles (Bedrosian & Nelson, 2017;

Hankins et al., 2007; Hartmann et al., 2021; Paul et al., 2009). Using knock-out mice, studies have indicated that animals that do not produce melanopsin are able to entrain to light signals, but at a lesser degree than wild-type controls (Bedrosian & Nelson, 2017; Hartmann et al., 2021). Further, evidence has shown that melanopsin responds most strongly to blue wavelengths of light (approximately 480nm; high levels during the day) than red wavelengths of light (greater than 600 nm; Bedrosian & Nelson, 2017). These cells are receptive to external lighting conditions and can initiate an action potential that is sent through the optic nerve through the optic chiasm via phototransduction (Arshavsky et al., 2002; Bedrosian & Nelson, 2017). This information is then sent to the SCN of the hypothalamus, which coordinates the 'circadian pacemaker' through translational and transcriptional feedback loops to establish a circadian rhythm (Hastings et al., 2007).

Two families of clock genes, *Period* and *Cryptochrome*, are also highly involved in entrainment of circadian rhythms (for review, see Hastings et al., 2007). Through Clock and Bmal1 proteins, *Period* (i.e., *Per1, Per2,* and *Per*3) and *Cryptochrome* (i.e., *Cry1* and *Cry2*) are activated at the onset of the circadian day (Hastings et al., 2007). Activation of these genes results in an increase in *Per* and *Cry* mRNA accumulation in the neurons of the SCN. This increase in mRNA is accompanied by an increase in Per and Cry proteins that peaks at the end of the circadian day. Because these proteins engage in negative feedback actions, this peak results in a reduction of *Per* and *Cry* mRNA (Hastings et al., 2007). In addition to this main feedback loop, accessory pathways are involved in establishing circadian rhythms. Having multiple loops allows for redundancy in genetic influence on circadian entrainment, meaning multiple systems can affect

entrainment in the event of alterations to one loop (Hastings et al., 2007). It is believed that several hundred SCN genes are involved with circadian activity (Hastings et al., 2007; Panda et al., 2002).

The circadian pacemaker is maintained by biological oscillators: "cells or groups of cells that show that cyclic changes in their physiology…" (Herzog, 2007, p. 790). When these biological oscillators can maintain rhythms and direct other cells, they are referred to as pacemakers (Herzog, 2007). Circadian pacemakers, such as the neurons of the SCN, can synchronize (i.e., entrain) to environmental cues such as daily or seasonal lighting conditions (Herzog, 2007; Hofstra & de Weerd, 2008). Several animal studies have demonstrated the sufficiency and necessity of the SCN in maintenance of circadian entrainment (Antle & Silver, 2005; Herzog, 2007; Kriegsfeld et al., 2004; Meyer-Bernstein et al., 1999; Ralph et al., 1990). Lesioning the SCN of mammals has been shown to disrupt circadian synchronization (Herzog, 2007; Kriegsfeld et al., 2004; Meyer-Bernstein et al., 1999; Ralph et al., 1990). Additionally, implantation of fetal SCN neurons into the third ventricle have resulted in circadian entrainment coordinated with the donor SCN (Antle & Silver, 2005; Herzog, 2007). The SCN, however, is not the only circadian pacemaker found in mammals (Bedrosian & Nelson, 2017; Golombek & Rosenstein, 2010). What are referred to as peripheral oscillators are found throughout the body, potentially being responsible for localized circadian rhythms (Golombek & Rosenstein, 2010). Thus, the SCN can be thought of as entraining these peripheral oscillators is the same sense that the SCN itself is entrained by the daily light-dark cycle.

The endogenous period of the biological clock is close to, but not exactly, 24 hours (Golombek & Rosenstein, 2010; Hofstra & de Weerd, 2008). Without

environmental cues[2] or the ability to synchronize to those stimuli, mammalian circadian clocks will rely on endogenous control of circadian activity and often engage in 'free-running' patterns (Golombek & Rosenstein, 2010). Free-running rhythms are those that deviate from a 24-hour cycle and are indicative of the internal period for the organism (Jud et al., 2005). In humans, free-running circadian period is slightly longer than 24 hours (Etain et al., 2011), and can be observed in some blind people or in sighted people living in isolation from external time cues.

One interesting phenomenon that has occurred with the onset of artificial light is a change to the circadian cycle as this artificial light is still received by the ipRGCs (Bedrosian & Nelson, 2017). Indeed, artificial light may be a contributing factor toward abnormal synchronization (Bedrosian & Nelson, 2017). Circadian rhythms, specifically abnormal entrainment, has been associated with a number of health risks such as mood disorders (Bedrosian & Nelson, 2017; Etain et al., 2011; McClung, 2013; Milhiet et al., 2011), cancer (Bedrosian & Nelson, 2017; Golombek & Rosenstein, 2010), psychiatric disorders (Bedrosian & Nelson, 2017), and alcoholism (Rosenwasser & Fixaris, 2013). Relevant to this thesis, implications of poor sleep (which is under circadian control; Czeisler & Gooley, 2007) have often been associated with both substance use problems (Hasler & Pedersen, 2020) and psychopathic traits (Akram et al., 2019; Drinkwater et al., 2020; Yang et al., 2019).

[2] Environmental cues can be temperature, tide, moonlight, food availability, social contacts (Golombek & Rosenstein, 2010), but most notably, light (Çalıyurt, 2017; Golombek & Rosenstein, 2010; Hofstra & de Weerd, 2007; Schmidt et al., 2011).

Circadian Rhythms and Mood/Behavior

Certain mood and psychiatric disorders have been associated with delinquent behavior (Ryan & Redding, 2004). McClung (2013) states that a large body of research dedicated to understanding the relationship between circadian rhythm abnormalities and mood disruption seems to suggest that circadian rhythms are the driving factor behind mood disruptions and not vice versa. Nevertheless, it is important to note that mood disorders also have an effect on circadian abnormalities, contributing to a positive feedback loop (Etain et al., 2011). Further, this suggests the presence of a bidirectional relationship between circadian entrainment and mood disorders.

Specifically, depression is often accompanied by problems in both sleep quality and duration (Steiger & Pawlowski, 2019), expressed as either too much sleep or too little sleep with increased feelings of tiredness and fatigue. These symptoms can be, in part, related to either "feelings of tiredness, fatigue and poor sleep…, or inducting sleepiness and deep sleep" (Garbarino et al., 2020, p.4; see also Vgontzas et al., 2015).

Further, increased activation of the HPA axis has been associated with sleep deprivation, insomnia, and other sleep disorders (Buckley & Schatzberg, 2005). Increased activation of the HPA may work to increase norepinephrine levels (Buckley & Schatzberg, 2005). This, in turn, works to increase electroencephalogram (EEG) frequencies, thereby decreasing sleep (Buckley & Schatzberg, 2005). Taken together, these results indicate that sleep is highly influential in HPA axis effects on mood. This has important implications for treatment for delinquency as increased mood has long been associated with increased adaptive and prosocial behaviors (George, 1991).

Another common framework used by researchers to assess the relationship between circadian rhythms and mood considers lighting conditions (Bedrosian & Nelson, 2017). Circadian rhythms have been shown to influence mood states, possibly through increased artificial lighting conditions (Bedrosian & Nelson, 2017; McClung, 2013). Bedrosian and Nelson (2017), as well as McClung (2013), have stated that increased use of screens, particularly at night, have been linked to increased instances of circadian disruption and mood disorders. In addition, molecular correlates of circadian disruption have been related to mood disorders (Etain et al., 2011; McClung, 2013; Milhiet et al., 2011).

While several environmental conditions have been identified as impacting the relationship between circadian rhythms and mood/behavior, there are also important biological factors to consider as well. In animal model studies, it has been observed that many genes involved with circadian entrainment may also be involved in mood disorders (McClung, 2013). These findings have been observed indirectly in humans, indicating a robust relationship between mood and clock genes (Etain et al., 2011; McClung, 2013; Milhiet et al., 2011). For example, Etain and colleagues (2011) have indicated that circadian rhythm alterations may serve as a biomarker for certain mood disorders. In a review of the current literature regarding mood spectrum disorders and circadian rhythms, Etain and colleagues (2011) determined several possible genetic factors leading to the development of mood disorders as a result of circadian entrainment abnormalities. Specifically, polymorphisms of *CLOCK, NPAS2, ARNTL1, PER3* and *NR1D1* are associated with bipolar disorder across various measures of circadian rhythms and various mood and psychiatric disorders and comorbities (Etain et al., 2011). Therefore,

circadian gene susceptibility has emerged as a possible mediator for the association between mood spectrum disorders and circadian rhythm desynchronization (Etain et al., 2011), as well as in the observed circadian disruption-bipolar disorder associations (Etain et al., 2011; Milhiet et al., 2011).

Studies have also shown that circadian rhythm abnormalities may serve as a biomarker for bipolar disorders specifically (Milhiet et al., 2011). In a review of genetic factors of circadian rhythms and bipolar disorder, Milhiet and colleagues (2011) demonstrated that circadian alterations have been observed in both periods of mania and depression, as well as euthymic periods suggesting the potential for "internal circadian clock machinery" (p. 183) to drive dimensions of bipolar disorder (Milhiet et al., 2011). Specifically, circadian influence of monoamine neurotransmitters (e.g., serotonin, dopamine, and norepinephrine) impacts mood (Milhiet et al., 2011). Milhiet and colleagues (2011) also reviewed the literature indicating that polymorphisms of circadian genes have been implicated in phenotypic expression of bipolar disorder as well as patients' treatment response. Though several mechanisms have been proposed for the circadian effect on mood, circadian regulation of the HPA axis (McClung, 2013) and role of serotonin (Milhiet et al., 2011) has emerged as a relevant hypothesis in the scope of this thesis.

Circadian Rhythms and Alcohol

Circadian entrainment has been studied extensively as it relates to alcohol consumption. To date, researchers have been unable to elucidate the causal neurobiological mechanisms of many complex human behaviors. To study chronobiological influences on alcohol consumption in humans, chronobiologists have

largely relied on animal models (Rosenwasser & Fixaris, 2013). In animal studies, a bidirectional relationship has been established (Meyrel et al., 2020; Rosenwasser & Fixaris, 2013; Spanagel et al., 2005). It has been observed that mice drink less in constant darkness (i.e., DD) and in constant light (i.e., LL) compared to light-dark (LD) 12:12[3] lighting regimens (Rosenwasser et al., 2020). Some of the earlier animal studies conducted on alcohol and circadian entrainment focused specifically on housing different breeds of rats in either constant light or constant dark (Sinclair & Geller, 1972). Though this early work had many limitations and methodological issues, the authors found that alcohol consumption varied by lighting condition and breed of rat. Sinclair and Geller (1972) found that drinking patterns in albino rats varied from that of other breeds, possibly due to the lack of eye pigmentation. This lack of pigmentation could allow for more light to be received by the retina, even at times when the rats' eyes are closed, thus affecting their circadian entrainment. This finding has prompted several recent studies investigating the role of melanopsin[4], a novel photopigment secreted by the ipRGCs, in circadian entrainment and alcohol consumption (Bedrosian & Nelson, 2017; Hankins et al., 2007; Hartmann et al., 2021; Paul et al., 2009; Schmidt et al., 2011).

Recent animal studies have also investigated the role of mice strain by lighting condition by alcohol consumption interactions (Rosenwasser & Fixaris, 2020). In this study (Rosenwasser & Fixaris, 2020), C57BL/6 (B6) and DBA/2 (D2)[5] mice strains were

[3] The ratio 12:12 refers to a lighting regiment in which animals are housed in 12 hours of light and 12 hours of dark (Rosenwasser et al., 2020).

[4] Melanopsin is a novel photopigment that is secreted in ipRGCs. Studies have indicated that a lack of melanopsin expression has led to decreased photosensitivity in circadian entrainment. It has also been implicated in the relationship between circadian entrainment and alcohol consumption in mouse model studies. However, knock-out studies have indicated that oblation of ipRGC-SCN connection may be more important for circadian entrainment than melanopsin production (Hartmann et al., 2021).

[5] In mice bred to display specific phenotypic responses to alcohol, B6 mice tend to show an increased level of preference for ethanol consumption and a decreased sensitivity to intense withdrawal symptoms, such as

observed regarding their ethanol consumption in LD 12:12, LL, and DD lighting conditions. Findings from this study demonstrated that B6 mice showed reduced ethanol consumption in LL and both strains showed reduced ethanol intake in DD conditions (Rosenwasser & Fixaris, 2013). This finding suggests that while environmental lighting conditions can alter voluntary ethanol consumption, genetic variability can also differentially impact the effect of lighting condition of ethanol intake (Rosenwasser & Fixaris, 2013). In human studies, similar findings have indicated that "sleep/circadian modulation of reward-related behavior" (Hasler & Pedersen, 2020, p. 58) may be related to alcohol consumption. Specifically, the impact of circadian entrainment on sensation seeking and impulse control may lead to a greater tendency to use substances, particularly as this behavior may activate a positive or negative reinforcement system (Hasler & Pedersen, 2020). For example, Hasler and Pedersen (2020) reviewed the current literature on adolescent substance use in relation to sleep/circadian characteristics and found two prominent models. Specifically, both substance use and novelty/reward seeking have been associated with a greater preference for eveningness[6] (Hasler & Pedersen, 2020; Pieters et al., 2010). Indeed, studies have proposed that individuals may be more sensitive to the rewarding properties of alcohol with later sleep timing (Hasler & Pedersen, 2020; Hasler et al., 2019). Further, Hasler and Pedersen (2020) propose that alcohol may be considered a sleep aid through its sedative-anxiolytic properties. Though evidence has indicated that long-term alcohol consumption reduces duration and quality of sleep, roughly 67% of insomniacs feel that alcohol is an effective sleep aid (Hasler & Pedersen,

seizures. Alternatively, D2 mice tend to be more sensitive to the withdrawal symptoms associated with alcohol with a decreased preference for ethanol consumption (Rosenwasser & Fixaris, 2013).

[6] Eveningness refers to a preference for the evening, and typically going to bed later in the evening.

2020). It is likely that this perception stems from a reduction in symptoms of anxiety that often lead to insomnia (Hasler & Pedersen, 2020).

Further, Rosenwasser and Fixaris (2013, p. 140) have indicated that "human alcoholics display dramatic disruptions of circadian rhythms that may contribute to the maintenance of excessive drinking, thus creating a vicious cycle." Additionally, those with a greater preference for eveningness may be more inclined to consume alcohol (Gulick & Gamsby, 2017; Hasler & Pedersen, 2020; Lemoine et al., 2013; Meyrel et al., 2020). This has suggested that there is a possible association between later onset of sleep and alcohol consumption.

In addition to studies investigating the role of circadian disruption on alcohol consumption, studies have reported a bidirectional relationship in which alcohol consumption may also alter circadian rhythm entrainment (Meyrel et al., 2020; Rosenwasser & Fixaris, 2013; Spanagel et al., 2005). For example, animal studies have indicated that exposure to LL and DD conditions alters ethanol intake, while ethanol intake in turn affects activity patterns (Rosenwasser & Fixaris, 2013). Meyrel and colleagues (2020) have indicated that dose-dependent biological rhythm changes are observed following acute alcohol consumptions in humans. These changes increase in intensity and duration in patients with Alcohol Use Disorder (AUD) and in periods of withdrawal (Meyrel et al., 2020). Meyrel and colleagues (2020) indicate that those with an evening chronotype may be more likely to experience AUD indicated by their circadian disruptions (Gulick & Gamsby, 2018; Lemoine et al., 2013). The authors further found that rhythmic hormone secretion, specifically cortisol and melatonin, showed greater alterations following high acute alcohol intake than low acute alcohol

intake. This study also indicates differential alterations between individuals with acute alcohol consumption and those with heavy chronic use (Meyrel at al., 2020).

Alcohol and Psychopathy

Psychopathy is thought to be characterized by a desensitization toward others and an internalization of antisocial behaviors (Levenson et al., 1995). Factors that are often associated with psychopathic traits include lying, cheating, being easily bored, impulsivity, callousness, unemotionality, and egocentrism (Levenson et al., 1995). Recent literature has evaluated the psychometric properties of psychopathy, generally finding support for use of a two- or three- factor model (Armstrong et al., 2020; Sellbom, 2011). The three-factor model of psychopathy is comprised of an egocentric, callousness, and antisocial factor whereas the two-factor model combines the egocentric and callousness factors (Sellbom, 2011). Further, several studies have indicated a robust relationship between alcohol use and psychopathy (Hawes et al., 2015; Kramer et al., 2017; LaLiberte & Grekin, 2015). Hawes and colleagues (2015) have indicated the presence of a bidirectional relationship between alcohol use and psychopathy. Specifically, alcohol use may work to increase the tendency for certain traits related to psychopathy (Hawes et al., 2015; Lejuez et al., 2010) and earlier alcohol use may contribute to neurobiological deficits contributing to further psychopathic behavior (Clark et al., 2008; Hawes et al., 2015; Squeglia et al., 2009; Volkow & Li, 2005).

A few recent studies have indicated a relationship between heavy alcohol use and Factor 2 psychopathy specifically (Kramer et al., 2017; LaLiberte & Grekin, 2015). LaLiberte and Grekin (2015) propose behavior activation (BAS) and positive alcohol expectancies (PAE) as mechanisms for this relationship. Gray and McNaughton (2000),

as cited by LaLiberte and Grekin (2015), postulate that the BAS is related to the biological reward system. It follows, then, that those with a strong BAS, often observed in individuals displaying Factor 2 psychopathic traits, will be more sensitive to and motivated by rewards (LaLiberte & Grekin, 2015). Further, PAE may play a mediating role in the relationship between increased alcohol consumption among heavy drinkers scoring high in Factor 2 psychopathy.

To test this, LaLiberte and Grekin (2015) used a sample of 196 undergraduate students. Including measures of psychopathy, behavioral activation, PAE, alcohol use and short-term memory, the study used structural equation modeling and found that 39% of the variance in alcohol use could be explained by Factor 2 psychopathy, BAS, and PAE. The study uncovered several significant direct and indirect effects between Factor 2 psychopathy, BAS, PAE, and alcohol use. LaLiberte and Grekin (2015, p. 263) concluded that "overall, the indirect effect of FTP on [alcohol use] was significant (η = 0.21, $p<0.001$), and accounted for 100% of the variance in the [Factor 2 psychopathy/Alcohol use] relationship." One of the first studies investigating the pathways relating Factor 2 psychopathy and drinking, it indicates that those more sensitive to the rewards of alcohol may also be likely to display psychopathic traits. However, this model ignores the role circadian entrainment plays in mood, behavior, and impulsivity traits.

Circadian Rhythms and Psychopathy

There are few studies that have investigated the associations between circadian rhythms and psychopathy (Akram et al., 2019). However, there are several studies indicating associations between alterations to circadian entrainment or sleep and various

related psychopathologies such as borderline personality disorder (Fleischer et al., 2012; Huýnh et al., 2016), ASB (Clinkinbeard et al., 2011; Mears et al., 2020), and Dark Triad Personality Traits (Drinkwater et al., 2020; Yang et al., 2019). These studies have highlighted the importance sleep has in modulating delinquent behavior. Taken together, the research clearly demonstrates that sleep affects a wide range of behavior and health outcomes (Clinkenbeard et al., 2011).

Previous studies have indicated that individuals displaying higher levels of Dark Triad Personality Traits also show a greater preference for eveningness; Akram et al., 2019; Jonason et al., 2013). Akram and associates (2019) have hypothesized that mental illnesses such as anxiety and depression mediate the relationship between evening preference and Dark Triad Traits. Focusing specifically on non-circadian influences on sleep and psychopathy, psychopathy and depression are significant predictors of chronotype disposition (Akram et al., 2019). In other words, this study found that an increased preference for the evening was predicted significantly by psychopathic tendencies (Akram et al., 2019).

In addition, studies investigating the sleep patterns of adolescents with borderline personality disorder (BPD) and bipolar disorder (BD) found differential sleep patterns among participants (Huýnh et al., 2016). In their exploratory study, Huýnh and colleagues (2016) found that on days participants were to report to school or work, individuals with BD reported greater quality and duration of sleep than either BPD or healthy controls (HC). Specifically, adolescents with BPD spent, on average, 7.9% (BPD: $21.5 \pm 6.6\%$; BD: $13.6 \pm 7.2\%$; $p = 0.04$) more time in bed awake compared to patients with BD (Huýnh et al., 2016). Additionally, BD and BPD patients reportedly slept longer

than HC participants on days individuals did not need to report to school or work (Huýnh et al., 2016). Specifically, adolescents with BD and BPD rose about an hour later than HC individuals on schedule free days (Huýnh et al., 2016). Finally, Huýnh and associates (2016) found that BPD adolescents showed higher variability in sleep patterns relative to BD or HC groups. The authors proposed several explanations for their findings. Generally, hypothesized mechanisms for these differences are rooted in therapeutic efforts to ameliorate symptoms of the disorders (Huýnh et al., 2016). One such hypothesis is the use of medication in patients with BD compared to those with BPD (Huýnh et al., 2016).

Clinkenbeard and colleagues (2011) have demonstrated that too little sleep associates with increased violent delinquency. Specifically, sleep totaling five hours or less associated with greater instance of violent behavior whereas sleep totaling seven hours or less associated with greater instance of property delinquency relative to adolescence sleeping eight to ten hours a night (Clinkenbeard et al., 2011). More recently, Mears and colleagues (2020) indicate that both too little and too much sleep may lead to increased delinquent behavior. It is hypothesized that this association may be due to "reduced self-control, greater strain, more susceptibility to peer influence, and impeded social bonds" (Mears et al., 2020, p. 21). Mears and colleagues (2020) recommend future studies to operationalize sleep as a categorical variable as opposed to a continuous one. As such, the current study will address this limitation by 'binning' participants into poor and adequate sleep groups.

Several studies have shown that sleep disturbances may be caused by and/or influence Dark Triad Personality Traits (Yang et al., 2019). Yang and colleagues (2019)

indicated that Machiavellianism and psychopathy relate to poor quality of sleep. Further, secondary psychopathy seems to be more strongly related to poor sleep (Yang et al., 2019).

The Current Study

As reviewed above, several complex and bidirectional relationships exist among the main variables of interest for this study. Clinical and experimental research has indicated that psychopathy and alcohol exert bidirectional influence on one another (Hawes et al., 2015; LaLiberte & Grekin, 2015; Kramer et al., 2017), particularly for people engaging in early, adolescent alcohol use (Clark et al., 2008; Hawes et al., 2015; Squeglia et al., 2009; Volkow & Li, 2005). Additionally, extensive literature has indicated that alcohol use and circadian entrainment are bidirectionally related as well (Meyrel et al., 2020; Rosenwasser & Fixaris, 2013; Spanagel et al., 2005). Finally, mood and circadian entrainment may also share a bidirectional relationship with one another (Etain et al., 2011; McClung, 2013), though it appears that circadian disruption may exert greater influence on mood than vise versa (McClung, 2013). This thesis, however, focuses specifically on the psychopathy to alcohol use relationship and the potentially moderating and mediating effects of circadian entrainment on that pathway.

Given the widespread impact of circadian entrainment on mood, behavior, and substance use it was hypothesized that poor circadian entrainment will have a robust influence on the psychopathy - alcohol relationship, potentially serving as a mediator and/or moderator of the association. Recent criminological studies have investigated the role sleep plays in the development of antisocial and psychopathic behavior but have not addressed the possibility of underlying circadian entrainment abnormalities driving this

observation. Through an interdisciplinary approach, the current thesis addresses this gap in the literature by exploring circadian entrainment as a potential mechanism in the psychopathy - alcohol relationship. Several hypotheses were tested: 1) that the relationship between psychopathy and alcohol use would become stronger with weaker circadian entrainment, 2) that circadian entrainment would have a mediating role in the psychopathy – alcohol relationship in that the relationship will no longer be significant when circadian entrainment is controlled for, 3) that circadian entrainment would have a mediating and or moderating role in the relationship between egocentric factor psychopathy, specifically, and alcohol use, 4) that circadian entrainment would have a mediating and/or moderating role in the relationship between callousness factor psychopathy and alcohol use, and finally, 5) that circadian entrainment would have a mediating and/or moderating role in the antisocial factor psychopathy – alcohol use relationship.

CHAPTER III

Methodology

Sample

The current thesis used data collected from undergraduate students from a large southern university in the fall of 2016. Data for this thesis are part of a larger data set comprised of a self-report survey administered during criminal justice courses capturing various antisocial behaviors and victimization, as well as certain health assessments. Additional laboratory measures were collected focusing on heart rate reactivity, salivary cortisol/testosterone measurements, and DNA samples after Institutional Review Board (IRB) approval. After signing informed consent, 872 individuals participated in a self-administered survey and 567 of those participants also participated in the laboratory portion of data collection. The current analytical sample is comprised of the 567 participants that completed the lab protocol portion of data collection, with a total of 371 participants with complete data. Average age for participants is around 20 years old, ranging from 18-47. Approximately 67% of participants (n = 378) are female. Further, about 38% (n = 214) participants are Hispanic, about 35% (n = 201) are White, about 13% (n =73) are Black, and the remaining 10% of participants (n = 56) are Asian, Hawaiian or Pacific Islander, American Indian, or other. Race/ethnicity was dichotomized in this study into Non-white (=0) and White (=1). Roughly 64% (n = 351) of participants came from homes with household income of $70,000 or less.

Measures

Independent Variable

Psychopathy. Psychopathy was measured using 19 items from the Levenson Self-Report Psychopathy (LSRP) scale, which was designed for non-incarcerated participants (Levenson et al., 1995; Sellbom, 2011). Participants were asked how much they agree with statements such as “in today’s world, I feel justified in doing anything I can get away with to succeed”, “my main purpose in life is getting as many goodies as I can”, and “I enjoy manipulating other people’s feelings”. All items were measured on a 4-point Likert response scale with responses ranging from “strongly disagree” (0) to “strongly agree”. Psychopathy was analyzed through a three-factor model (e.g., callousness, egocentricity, antisocial), consistent with findings from Sellbom (2011) and Armstrong et al. (2020). Factor 1 psychopathy (i.e., egocentricity) is comprised of 10 items from the LSRP. Factor 2 psychopathy (i.e., callousness) is made up of 4 items from the LSRP. Finally, Factor 3 psychopathy (i.e., antisocial) includes 5 items from the LSRP. Specific items included in each factor can be found in the appendix.

Circadian Rhythm Entrainment

Sleep. Circadian entrainment was measured using sleep timing as a proxy measure. Timing of sleep was measured by asking respondents “what time do you normally go to bed?”. For this analysis responses were coded in one-hour increments ranging from 11 to 28 such that midnight was coded as “24”, 0100 coded as “25”, 0200 coded as “26”, 0300 coded as “27”, and 0400 is coded as “28”. Because time is a circular variable, but circular statistics were beyond the scope of this thesis, this coding allowed for analysis by comparing those going to bed relatively early in the night to those that go

to bed relatively late in the night. Circadian entrainment was measured as a continuous variable in this study.

Dependent Variable

Alcohol Use. Alcohol use was measured using one item derived from the National Youth Survey Substance Use (Elliott et al., 1982). Measured on a Likert scale ranging from "Never" (0) to "2-3 times a day" (8), participants were asked "how often, in the past year, have you used alcoholic beverages, beer, wine, hard liquor"? Most participants reported at least having drank once in the last year. The mean was 2.68, meaning on average, participants consumed alcohol around once a month.

Control Variables

Parental Attachment. Parental attachment was measured using 9 items derived from Kenny's Parental Attachment Questionnaire (1987). Items measured participants general attitudes toward their parents. Participants were asked to rate on a Likert scale how well various statements described their parents. Items included questions such as "in general, my parents: are persons I can count on to provide emotional support when I feel troubled; support my goals and interests; understand my problems and concerns; have no idea what I am feeling or thinking; are too busy or otherwise involved to help me; ignore what I have to say; are sensitive to my feelings and needs; are disappointed in me; and are persons whose expectations I feel obligated to meet." Responses range from 0 ("Not at all") to 4 ("Very Much"). Of the 9 items included, 4 were reverse coded to indicate higher values corresponding with higher levels of parental attachment.

Depression. Depression was measured using 20 items from the Center for Epidemiologic Studies Depression Scale Revised (CESD-R; Eaton et al., 2004).

Questions asked participants how frequently the statement was true for the participant recently. Examples include statements such as “My appetite was poor”, “I could not shake off the blues”, and “I felt depressed”. Responses ranged from 0 (“Never”) to 8 (“2-3 times a day”). Internal reliability for this measure was excellent (Cronbach’s alpha = 0.97).

Antisocial Behavior. Antisocial behavior was measured using 38 items from the National Youth Survey’s (Elliott, 2009) delinquency measure. Questions asked participants how often, in the past year, certain statements applied to them. Examples include “how often, in the past year, were you involved in purposely damaging or destroying other property that did not belong to you, not county family, or work property”, “attacking someone with the idea of seriously hurting or killing that person”, “selling hard drugs such as heroin, cocaine, and LSD”, or “snatching someone’s purse or wallet or picked someone’s pocket”. Responses ranged from 0 to 8 (0 = “never”, 1 = “once or twice”, 2 = “once every 2-3 months”, 3 = “once a month”, 4 = “once every 2-3 weeks”, 5 = “once a week”, 6 = “2-3 times a week”, 7 = “once a day”, and 8 = “2-3 times a day”). Internal reliability for this measure was good (Cronbach’s alpha = .773).

Demographic Control Variables. The current thesis included 4 demographic control variables in addition to parental attachment and depression. Demographic information regarding participants’ age, race, sex, and socioeconomic status was collected as part of the self-administered survey. Age is measured as a continuous variable ranging from 18 to 27. Participant’s race and ethnicity were dichotomized into 0 (“Non-white”) and 1 (“White”). Sex was dichotomized into 0 (male) and 1 (female; two participants were excluded from analysis that chose “other” for their sex). Socioeconomic

status was measured by asking participants “approximately what was your family’s annual income when you were growing up?” Responses ranged from 0 (“Less than $20,000”) to 6 (“Over $100,000).

Plan of Analysis

The plan of analysis for this study was to assess bivariate correlations between the variables of interest and demographic and theoretically relevant controls. Based on these correlations, Ordinary Least Squares regression models were used to assess the ability of these variables to predict alcohol use in the college sample. Significant correlations from circadian entrainment indicate the possibility of mediation, however the data is cross-sectional. Establishing causal mediation of circadian entrainment, therefore, is not possible. An interaction term between each of the psychopathy measures and circadian entrainment was analyzed in OLS regression models to test moderation of circadian entrainment in the relationship between psychopathy and alcohol use. Psychopathy was first tested as a full measure, but based on insignificant regression results, it was also tested as a three-factor model.

Table 1

Descriptive Statistics for the Full Sample (N = 371)

Variables	M	SD	Range
Psychopathy	17.6	7.08	0-42
Egocentric	8.77	4.40	0-24
Callousness	3.59	2.00	0-10
Antisocial	5.20	2.54	0-13
Circadian Rhythm	7:51	1:28	4:30-19:30
Alcohol Use	2.68	2.11	0-8
Depression	37.39	33.52	0-160
Parental Attachment	27.30	7.04	0-36
Socioeconomic Status	3.57	1.87	0-6
Age	20.22	2.77	18-47
Gender			
Male*	32.5%	-	-
Female	67.5%	-	-
Race/Ethnicity			
Non-White*	61.8%	-	-
White	38.2%	-	-

* Reference Category

CHAPTER IV

Results

To reiterate, the analytic strategy for this study was to: 1. examine the bivariate correlations between the main variables of interest and demographically and theoretically relevant controls, 2. perform an Ordinary Least Squares (OLS) analysis, and 3. perform mediator and moderator analyses using OLS based on the results of the previous two steps. Table 2 shows the bivariate correlations between all variables included in the full sample for this study, reporting the Pearson's correlation coefficient. Alcohol use was statistically significantly related to the fully psychopathy measure (r = .236, p <.001), egocentric psychopathy (r = .220, p <.001), callousness psychopathy (r = .109, p = .042), antisocial psychopathy (r = .177, p = .001), the circadian entrainment measure (r = .131, p = .014), depression (r = .171, p = .001), antisocial behavior (r = .434, p < .001), age (r = -.383, p < .001), race and ethnicity (r = .133, p = .013), and family income (r = .126, p = .018). The full psychopathy measure (r = .171, p = .001), egocentric psychopathy (r = .125, p = .020), callousness psychopathy (r = .142, p = .008), antisocial psychopathy (r = .136, p = .011), alcohol use (r = .131, p = .014), depression (r = .108, p = .043), and antisocial behavior (r = .120, p = .024) all significantly correlate with the circadian entrainment measure. The full psychopathy measure also significantly associated with antisocial behavior (r = .378, p < .001), parental attachment (r = -.267, p < .001), and gender (r = -.264, p < .001). Further, egocentric psychopathy was significantly related to antisocial behavior (r = .333, p < .001), parental attachment (r = -.254, p < .001), and gender (r = -.246, p < .001). Callousness psychopathy significantly associated with antisocial behavior (r = .211, p < .001), parental attachment (r = -.137, p = .011), and

gender (r = -.246, p < .001). Antisocial Psychopathy also was significantly related to depression (r = .322, p < .001), antisocial behavior (r = .289, p < .001), and parental attachment (r = -.183, p = .001).

Table 2

Correlations for All Variables (N = 350)

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Psychopathy													
1. Full Measure	-												
2. Egocentric	.901**	-											
3. Callousness	.618**	.414**	-										
4. Antisocial	.682**	.409**	.178**	-									
5. Circadian Entrainment	.171**	.125*	.142**	.136*	-								
6. Alcohol Use	.236**	.220*	.109*	.177*	.131*	-							
7. Depression	0.091	0.001	-.102	.322**	.108*	.171**	-						
8. Antisocial Behavior	.378**	.333**	.211**	.289**	.120*	.434**	.277**	-					
9. Parental Attachment	-.267**	-.254**	-.137*	-.183**	-.028	-.097	-.258**	-.179**	-				
10. Age	-.014	.005	-.055	-.002	-.007	-.383**	-.030	-.125*	.110*	-			
11. Gender	-.264**	-.251**	-.246**	-.093	-.093	-.010	.193**	-.037	.112*	.346	-		
12. Race and Ethnicity	-.026	-.070	.018	.032	-.067	.133*	.040	.003	-.069	-.023	-.121*	-	
13. Family Income	0.014	-0.007	0.035	0.022	.000	.126*	-.050	.130*	.117*	-.008	-.081	.33**	-

Note. ** p < .01; * p < .05.

In each of the regression tables, Model 1 shows regression results including the psychopathy measure of interest (i.e., Full, Egocentric, Callousness, and Antisocial) and each of the control variables. Model 2 includes the circadian entrainment measure. And finally, Model 3 shows results with the psychopathy measure, the circadian entrainment measure, and an interaction term between the psychopathy measure and the circadian entrainment measure. Table 3 shows results from the OLS regression analyses showing main, mediating, and moderating effects of the full psychopathy measure and circadian entrainment on alcohol use with the control variables included. Model 1 demonstrates a base model with only the full psychopathy measure and alcohol use. Circadian entrainment was not included in this model to demonstrate the potential mediating or moderating effects of circadian entrainment.

Model 1 shows that psychopathy ($\beta = .131$, $p = .011$), antisocial behavior ($\beta = .331$, $p < .001$), age ($\beta = -.343$, $p < .001$), and race and ethnicity ($\beta = .122$, $p = .011$) are all significant predictors of alcohol use in this college sample. In other words, scoring higher for psychopathy and antisocial behavior, as well as being younger and white predict greater frequency of alcohol use in this college sample. Model 2 shows the OLS regression results with the inclusion of the circadian entrainment measure. As demonstrated, psychopathy ($\beta = .120$, $p = .019$), antisocial behavior ($\beta = .328$, $p < .001$), age ($\beta = -.343$, $p < .001$), and race and ethnicity ($\beta = .128$, $p = .008$) are all significant predictors of alcohol use. Circadian entrainment ($\beta = .079$, $p = .082$), however, did not significantly predict alcohol use. Because the predictive power of psychopathy in this model remained significant, we can conclusively state that circadian entrainment is not a mediator of the psychopathy and alcohol use relationship. Model 3 includes an

interaction term between the full psychopathy measure and the circadian entrainment measure to demonstrate the potentially moderating effects of circadian entrainment on the relationship between psychopathy and alcohol use. Model 3 shows that scoring higher in psychopathy (β = .121, p = .019), scoring higher in antisocial behavior (β = .327, p < .001), being younger (β = -.344, p < .001), and being White (β = .132, p = .006) significantly predict greater frequency of alcohol use among college students. Model three also demonstrates that the interaction term (Full Psychopathy X Circadian Entrainment; β = .059, p = .186) is not a significant predictor of alcohol use among college students, indicating that circadian entrainment does not moderate the psychopathy alcohol use relationship.

Table 3

Regression Models Predicting Alcohol Use in the Full Sample (Full Psychopathy; N = 350).

	Model 1		Model 2		Model 3	
Variables	b (SE)	β	b (SE)	β	b (SE)	β
1. Psychopathy	.040 (.016)	.131*	.037 (.016)	.120*	.037 (.016)	.121*
2. Circadian Entrainment	-	-	.124 (.071)	.079	.118 (.071)	.075
3. Psychopathy X Circadian Entrainment	-	-	-	-	.014 (.010)	.059
4. Depression	.041 (.037)	.055	.034 (.037)	.046	.036 (.037)	.047
5. Antisocial Behavior	.577 (.088)	.331**	.571 (.088)	.328**	.570 (.088)	.327**
6. Parental Attachment	.015 (.016)	.046	.014 (.016)	.042	.013 (.016)	.039
7. Age	-168.822 (22.119)	-.343**	-168.871 (22.054)	-.343**	-169.217 (22.031)	-.344**
8. Gender	.249 (.214)	.056	.282 (.214)	.063	.285 (.214)	.064
9. Race and Ethnicity	.524 (.206)	.122*	.551 (.205)	.128**	.568 (.206)	.132**
10. Family Income	.046 (.055)	.040	.045 (.055)	.039	.041 (.055)	.036

Note. ** $p < .01$; * $p < .05$.

Table 4 shows regression analyses using the egocentric factor psychopathy. Model 1 demonstrates that egocentric psychopathy (β = .150, p = .003), antisocial behavior (β = .327, p < .001), age (β = -.346, p < .001), and race and ethnicity (β = .128, p = .008) are significant predictors of alcohol use in this study. In other words, scoring higher in the egocentric factor psychopathy specifically, scoring higher in antisocial behavior, being White, and being younger significantly predict greater frequency of alcohol use. Model 2 shows OLS regression results including the circadian entrainment measure in a predictive model with egocentric psychopathy for alcohol use. In this model, egocentric psychopathy (β = .143, p = .005), antisocial behavior (β = .323, p < .001), age (β = .346, p < .001), and race and ethnicity (β = .135, p = .005) all significantly predict alcohol use. Circadian entrainment (β = .082, p = .070), however, is not a significant predictor of alcohol use. Therefore, it does not serve as a mediator in the relationship between egocentric psychopathy and alcohol use. Model 3 shows regression results with egocentric psychopathy, circadian entrainment, and an interaction term between egocentric psychopathy and circadian entrainment. Results indicate that antisocial behavior (β = .318, p < .001), age (β = -.347, p < .001), and race and ethnicity (β = .140, p = .004) significantly predict alcohol use. Drinking behavior was not significantly predicted by the interaction term (β = .057, p = .199), indicating that circadian entrainment does not moderate the relationship between egocentric psychopathy and alcohol use.

Regression results including the callousness factor psychopathy are shown in Table 5. Model one shows results with only the callousness psychopathy measure and

control variables and indicates that antisocial behavior (β = .370, $p < .001$), age (β = -.335, $p < .001$), and race and ethnicity (β = .113, $p = .019$) are significant predictors of alcohol use in this college sample. Callousness psychopathy (β = .025, $p = .596$) was not significantly related to alcohol use. The lack of a significant relationship, then, indicates that further analysis is unnecessary to determine that circadian entrainment cannot serve as a mediator or moderator. Nevertheless, results for Model 2 (e.g., inclusion of the circadian entrainment measure; β = .090, $p = .051$) and Model 3 (e.g., inclusion of the callousness psychopathy X circadian entrainment; β = .035, $p = .439$) are shown in Table 5. Similarly, Table 6 shows regression results for antisocial factor psychopathy with a base model without circadian entrainment (Model 1), a model with circadian entrainment (Model 2), and a model with the interaction term between antisocial psychopathy and circadian entrainment (Model 3). Model 1 shows that antisocial factor psychopathy (β = .062, $p = .205$) does not significantly predict to alcohol use, but antisocial behavior (β = .364, $p < .001$), age (β = -.338, $p < .001$), and race and ethnicity (β = .113, $p = .019$) were significant predictors. Further analysis is not necessary to determine there are no mediating or moderating effects of circadian entrainment on the relationship between antisocial psychopathy and alcohol use, but results are nevertheless shown in table 6.

Table 4

Regression Models Predicting Alcohol Use in the Full Sample (Egocentric Psychopathy; 350)

	Model 1		Model 2		Model 3	
Variables	b (SE)	β	b (SE)	β	b (SE)	β
1. Psychopathy	.073 (.024)	.150**	.070 (.024)	.143**	.070 (.024)	.143**
2. Circadian Entrainment	-	-	.128 (.071)	.082	.125 (.071)	.079
3. Psychopathy X Circadian Entrainment	-	-	-	-	.021 (.016)	.057
4. Depression	.052 (.037)	.069	.044 (.037)	.059	.046 (.037)	.061
5. Antisocial Behavior	.571 (.087)	.327**	.562 (.087)	.323**	.554 (.087)	.318**
6. Parental Attachment	.017 (.016)	.053	.016 (.016)	.049	.015 (.016)	.046
7. Age	-170.280 (22.068)	-.346**	-170.500 (21.994)	.346**	-170.620 (21.973)	-.347**
8. Gender	.251 (.211)	.056	.290 (.212)	.065	.296 (.211)	.066
9. Race and Ethnicity	.552 (.205)	.128**	.580 (.205)	.135**	.603 (.206)	.140**
10. Family Income	.047 (.055)	.041	.046 (.055)	.040	.044 (.055)	.038

Note. ** $p < .01$; * $p < .05$.

Table 5

Regression Models Predicting Alcohol Use in the Full Sample (Callousness Psychopathy; N = 350)

	Model 1		Model 2		Model 3	
Variables	b (SE)	β	b (SE)	β	b (SE)	β
1. Psychopathy	.027 (.050)	.025	.015 (.050)	.014	.013 (.050)	.013
2. Circadian Entrainment	-	-	.141 (.072)	.090	.138 (.072)	.088
3. Psychopathy X Circadian Entrainment	-	-	-	-	.027 (.035)	.035
4. Depression	.044 (.038)	.059	.035 (.038)	.046	.035 (.038)	.046
5. Antisocial Behavior	.646 (.086)	.370**	.636 (.085)	.365**	.637 (.086)	.365**
6. Parental Attachment	.008 (.016)	.024	.007 (.016)	.021	.006 (.016)	.019
7. Age	164.828 (22.272)	-.335**	-165.282 (22.181)	-.336**	-165.290 (22.194)	-.336**
8. Gender	.131 (.212)	.029	.171 (.213)	.038	.172 (.213)	.039
9. Race and Ethnicity	.487 (.207)	.113*	.521 (.207)	.121*	.532 (.207)	.124*
10. Family Income	.045 (.056)	.040	.044 (.055)	.038	.044 (.055)	.039

Note. ** $p < .01$; * $p < .05$.

Table 6

Regression Models Predicting Alcohol Use in the Full Sample (Antisocial Psychopathy; N = 350)

	Model 1		Model 2		Model 3	
Variables	b (SE)	β	b (SE)	β	b (SE)	β
1. Psychopathy	.051 (.040)	.062	.045 (.040)	.055	.046 (.040)	.056
2. Circadian Entrainment	-	-	.137 (.071)	.087	.134 (.072)	.085
3. Psychopathy X Circadian Entrainment	-	-	-	-	.017 (.025)	.030
4. Depression	.028 (.039)	.037	.022 (.039)	.029	.022 (.039)	.029
5. Antisocial Behavior	.634 (.085)	.363**	.623 (.085)	.358**	.628 (.086)	.361**
6. Parental Attachment	.008 (.016)	.025	.007 (.016)	.023	.007 (.016)	.022
7. Age	-166.328 (22.254)	-.338**	-166.558 (22.167)	-.338**	-166.885 (22.191)	-.339**
8. Gender	.146 (.210)	.033	.190 (.210)	.043	.188 (.211)	.042
9. Race and Ethnicity	.487 (.206)	.113*	.520 (.206)	.121*	.516 (.207)	.120*
10. Family Income	.044 (.055)	.039	.043 (.055)	.038	.040 (.055)	.035

Note. ** $p < .01$; * $p < .05$.

CHAPTER V

Discussion

Extensive literature has been dedicated to better understanding the relationship between psychopathy and alcohol use and its far-reaching, negative individual and social impacts (Hawes et al., 2015; Kramer et al., 2017; LaLiberte & Grekin, 2015). Given the complex bidirectional relationships between alcohol use, circadian entrainment, and psychopathy, this study investigated the potential for circadian entrainment to serve as a moderator or mediator in the psychopathy – alcohol use pathway. Specifically, this thesis hypothesized that circadian entrainment moderates the relationship between psychopathy and alcohol use in that weaker entrainment will strengthen the association. Secondly, this thesis hypothesized that circadian entrainment would mediate the association between psychopathy and alcohol use in that the relationship would no longer exist when entrainment was included. Thirdly, this thesis predicted that circadian entrainment would serve as a mediator and/or moderator in the relationship between egocentric, callousness, and antisocial factor psychopathy individually and alcohol use.

However, based upon the results for this thesis, the above hypotheses must be rejected. Circadian entrainment and each measure of psychopathy were statistically significantly related to alcohol use, as shown in Table 2. Callousness factor and antisocial factor psychopathy did not significantly predict alcohol drinking in this college sample[7]. Indeed, only the full psychopathy and the egocentric factor psychopathy were significant predictors of alcohol use. Tables 3 and 4 indicate that neither circadian entrainment, nor

[7] There was, therefore, no relationship between these psychopathy factors and alcohol use for circadian entrainment to mediate or moderate. Analyses for these factors are demonstrated in Tables 5 and 6, but will not be discussed in great detail.

the interaction term created from the full or egocentric factor psychopathy and circadian entrainment, significantly predicted alcohol use. Taken together, results from this analysis indicate that circadian entrainment is neither a mediator nor moderator of the psychopathy to alcohol use pathway.

Though significantly correlated to alcohol use, Model 2 of Tables 3 and 4 demonstrate that inclusion of the circadian entrainment measure did not result in an insignificant predictive effect of the full and egocentric psychopathy factors. Therefore, I can conclusively state that circadian entrainment is not a mediator of the psychopathy and alcohol use relationship. Further, Model 3 of Tables 3 and 4 indicate that circadian entrainment does not serve as a moderator of the relationship between psychopathy and alcohol use.

One possible explanation for these results may be that serotonin (5-HT), rather than circadian entrainment, may be a driving factor in the psychopathy – alcohol use relationship. 5-HT has been shown to affect a number of structures and functions of the brain, including sleep-wake behavior, mood, alcohol consumption, and even certain characteristics of psychopathy (Mohammad-Zadeh & Gwaltney-Brant, 2008). It may be then, that serotonin levels may be more important than circadian entrainment in understanding the relationship between psychopathy and alcohol use.

Previous reviews have indicated that 5-HT may play a role in the development and maintenance of psychopathic traits (Yilidirim & Derksen, 2013). Current theories suggest that serotonin plays a vital role in neurodevelopment and helps to develop and maintain homeostatic operations within the brain (Yilidirim & Derksen, 2013). Proper 5-HT levels allow for cognitive and emotional functioning of the brain (Yilidirim &

Derksen, 203). Yilidirim and Derksen (2013) propose 5-HT levels may be responsible for reducing responsiveness to threat but do not affect social behavior and cognition which is often seen in those displaying high levels of psychopathy. It may be then, that 5-HT plays a mechanistic role in the association between psychopathy and circadian cycles. Further, previous research has investigated the role of 5-HT in substance use disorders, particularly alcoholism, finding that specific genotypes responsible for encoding 5-HT receptors can influence alcohol consumption (Johnson et al., 2011).

5-HT has also been studied as it relates circadian entrainment (Adriani et al., 2012; Nakamaru-Ogiso et al., 2012). Specifically, 5-HT has been shown to regulate diurnal sleep-wake cycles through a coupling process between those sleep-wake cycles and the SCN circadian pacemaker (Nakamaru-Ogiso et al., 2012). In their study, Nakamaru-Ogiso and colleagues (2012) demonstrated that depletion of 5-HT from tryptophan side chain oxidase (TSOI[8]) injection disrupts the sleep-wake cycle without changing the total amount of sleep in rodents. In addition, the loss of 5-HT from experimental treatment resulted in depression-like symptoms in rats (Nakamaru-Ogiso et al., 2012) providing support for 5-HT to serve as an important neurotransmitter in the psychopathy-alcohol use relationship.

It may also be likely that the participants in this study do not display the problematic alcohol drinking behavior that was discussed in previous literature. In relating psychopathy or circadian entrainment to alcohol use, some studies use a measure of alcohol abuse or alcohol use disorder. The alcohol use measure included in this study was not exhaustive and provides little information regarding problematic drinking

[8] TSOI is an enzyme that depletes tryptophan, a precursor to serotonin, thereby reducing serotonin levels (Nakamaru-Ogiso et al., 2012).

behaviors. It may be that this sample contains very little individuals that display alcohol use disorder, dependence, or abuse and do not fall beyond the normal and expected range. Therefore, there may not be enough extreme cases to show a relationship between circadian entrainment and alcohol consumption in the regression models.

Results from this study should not be interpreted without consideration for several limitations. First, this study used cross-sectional data, limiting the establishment of temporal ordering. As such, future studies should incorporate available longitudinal data that include sleep measures in humans. Second, this study uses restricted data collected as part of a larger data set designed to collect information regarding individuals' criminal activity, victimization, substance use, and several biomarkers for certain behavior. Several well-known and validated sleep quality and timing measures, such as the Pittsburgh Sleep Quality Index and the Morningness-Eveningness Questionnaire, were not included in initial collection for this data set. Items included in data collection attempt to tap into these measures but fall short in comparison. As such, this study does not use standard chronotype or sleep measures. Future studies investigating the role of circadian entrainment on criminogenic factors and substance use should incorporate use of these sleep and chronotype measures as part of the study. Finally, initial data collection only included one item regarding participants' alcohol use. Alcohol use in this study was measured as approximate frequency of alcohol consumption in the past 12 months and therefore does not distinguish between alcohol use and alcohol abuse. Future studies should include alcohol use items that distinguish between use and abuse. Future studies may also consider investigating sleep, alcohol use, and psychopathic measures among different population groups, including inmate and forensic populations.

Conclusion

This thesis hypothesized that weak circadian entrainment would mediate or moderate the association between full or three-factor models of psychopathy and alcohol use based on extensive prior literature indicating potentially robust bidirectional relationships between the three variables of interest. However, results from this thesis using a sample of undergraduate students do not support the above hypotheses. Circadian entrainment does not appear to mediate or moderate the psychopathy – alcohol use relationship, nor does it appear to predict alcohl use in regression analysis. The role of 5-HT may be an important future study in between understanding the relationships between circadian entrainment, psychopathy, and alcohol use. Better understanding of this relationship and the mechanisms that drive it can aid in better informing policy and treatment for individuals experiencing higher levels of psychopathy and alcohol use.

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APPENDIX

Levenson Self-Report Psychopathy Scale	
Factor	Items
1 (Egocentric)	In today's world, I feel justified in doing anything I can get away with to succeed.
	My main purpose in life is getting as many goodies as I can.
	I enjoy manipulating other people's feelings.
	I tell other people what they want to hear so that they will do what I want them to do.
	For me, what's right is whatever I can get away with.
	Success is based on survival of the fittest; I am not concerned about the losers.
	Making a lot of money is my most important goal.
	I let others worry about higher values; my main concern is with the bottom line.
	I often admire a really clever scam.
	People who are stupid enough to get ripped off usually deserve it.
2 (Callousness)	Even if I were trying very hard to sell something, I wouldn't lie about it.
	Cheating is not justifiable because it is unfair to others.
	I feel bad if my words or actions cause someone else to feel emotional pain.
	I make of point of trying not to hurt others in pursuit of my goals.
3 (Antisocial)	I am often bored.
	I quickly lose interest in tasks I start.
	I have been in a lot of shouting matches with other people.
	I find myself in the same kinds of trouble, time after time.
	When I get frustrated, I often "let off steam" by blowing my top.

VITA

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Education

2021-present Ph.D., Criminal Justice and Criminology
Sam Houston State University
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2019-present M.A., Criminal Justice
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2015-2019 B.S., Biology (minor: neuroscience)
University of Maine, Orono

***Senior Capstone**:* **Royle, M.**, & Rosenwasser, A. (2019). *The effects of environmental lighting on circadian rhythm entrainment and voluntary alcohol intake: Possible role for melanopsin signaling.*

Research Interests

Neurobiology
Substance Use
Sleep and Offending
Quantitative Research Methods

Publications in Progress

Royle, M. L., Boisvert, D., Armstrong, T., Wells, J., Lewis, R., & Cooke, E. (2021). The Relationship between Heart Rate Reactivity and Antisocial Behavior by Alcohol Use.

Royle, M. L., & Connolly, E. J. (2021). The Relationship Between Grit and Recidivism: Evidence from a Nationally Representative Sample of youth.

Conference Presentations

Royle, M. L., Boisvert, D., Armstrong, T., Wells, J, Lewis, R., & Cooke, E. (2020) The relationship between heart rate reactivity and antisocial behavior by alcohol use. Panel presentation accepted by the American Society of Criminology as part of the annual conference to be held in Washington D.C. in November of 2020. This conference was canceled due to concerns regarding COVID-19.

McCulley III, W.D., Hartmann, M.C., Brooks, R., **Royle, M.**, Howell, A., Hattar, S., & Rosenwasser, A.M. (2019). The effects of environmental lighting on circadian rhythm entrainment and voluntary alcohol intake: Possible role for melanopsin

signaling. Poster presented at the Maine Society for Neuroscience meeting, held in Gorham, ME and at the University of Maine CUGR Student Symposium, held in Bangor, ME.

University Experience

2020-presentGraduate Research and Teaching Assistant
Department of Criminal Justice and Criminology
Sam Houston State University

Assisted Dr. Danielle Boisvert in ongoing biosocial criminology research projects. Assisted Dr. Kathleen Latz with grading, attendance, and Blackboard matters in three undergraduate sections of her Trauma and Crisis Intervention course, two graduate sections of her Non-Profit Grant Writing Course, and two graduate sections of her Advocacy and Case Management Course.

2019-2020Graduate Research Assistant
Department of Criminal Justice and Criminology
Sam Houston State University

Assisted Drs. Danielle Boisvert and Eric Connolly with ongoing biosocial criminology research projects.

2018-2019Undergraduate Research Assistant
Department of Psychology
University of Maine

Assisted Dr. Alan M. Rosenwasser in his chronopsychobiology lab with his project involving circadian rhythm and alcohol research. Assisted in everyday lab maintenance, data collection, entry, analysis, and writing.

Service

2021-presentPresident of the Criminal Justice Graduate Student Organization

Lead the CJ GSO, serve as a liaison between students and faculty, organize events held by the GSO (i.e., professional development workshops, check-ins with students, social events), serve as a representative for the GSO and other organizations on campus, lead monthly General Meetings.

2020-presentSecretary of the Criminal Justice Graduate Student Organization

Organize events held by the CJ GSO (i.e., professional development workshops, check-ins with students, social events), serve as a liaison between students and faculty, and assist with communication and note taking during monthly General Meetings.

2019-2020Member of the Criminal Justice Graduate Student Organization and participated in various service, social, and fundraising events hosted by the CJ GSO.

Awards

2019, 2018, 2017, 2016 University of Maine Scholar Athlete Award
2015 All-America East Conference Academic Team

Professional Organizations

American Society of Criminology
Academy for Criminal Justice Sciences