Evening chronotype, alcohol use disorder severity, and emotion regulation in college students

Briana J. Taylor[a,b], **Marissa A. Bowman**[a], **Alicia Brindle**[a], **Brant P. Hasler**[c], **Kathryn A. Roecklein**[a], **Robert T. Krafty**[d], **Karen A. Matthews**[a,c], **Martica H. Hall**[a,c]

[a]Department of Psychology, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

[b]Center for Psychiatric Research, Maine Medical Center, Portland, Maine, USA

[c]Department of Psychiatry, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, USA

[d]Department of Biostatistics, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

Abstract

The evening chronotype is strongly associated with greater alcohol use, though mechanisms underlying this association are not well understood. The current study evaluated emotion regulation as a potential mechanism linking evening chronotype and alcohol use. Participants were 81 undergraduate students. Chronotype was assessed using the Composite Scale of Morningness (CSM). Alcohol use disorder severity was assessed using the Alcohol Use Disorder Identification Test (AUDIT). Participants recorded daily sleep patterns using an online diary for seven days. Participants then completed a standardized laboratory emotion regulation task. Self-reported affect, high-frequency heart rate variability (HF-HRV), and pre-ejection period (PEP) were measured throughout the task. Sleep duration on non-free days (defined as days when sleep was restricted by morning obligations such as work or school) was evaluated as a moderator. Thirty-one evening chronotypes (CSM scores 26) were compared to 50 non-evening chronotypes (CSM scores >26). Evening chronotypes reported significantly greater symptoms of alcohol use disorder ($F = 4.399$, $p = .039$). In the full sample, emotion regulation was successful for altering affective but not autonomic reactivity to emotional stimuli. There were no chronotype differences in self-reported affect, HF-HRV, or PEP during the emotion regulation task. Longer sleep duration on non-free days was associated with increased HF-HRV during negative emotion regulation among non-evening chronotypes. Moderated mediation revealed that emotion regulation did not mediate the association between evening chronotype and alcohol use, irrespective of sleep duration on non-free days. This study is consistent with the literature on chronotype and substance use, demonstrating that undergraduate evening chronotypes endorse greater severity of alcohol use disorder. Given that emotion regulation did not successfully alter autonomic reactivity to emotional stimuli, emotion regulation as a potential mechanism linking chronotype and alcohol use remains inconclusive. Longer sleep duration appears to be protective

for non-evening chronotypes in terms of parasympathetic control during the regulation of negative emotions.

Keywords

Chronotype; alcohol; emotion regulation; HRV; autonomic

Introduction

The "evening chronotype", as defined by a preference for later sleep/wake or circadian timing, is associated with greater alcohol consumption (Prat and Adan 2011), binge drinking (Watson et al. 2013), and greater levels of alcohol dependence (Hasler et al. 2013). Emotion regulation may be one potential mechanism linking chronotype and alcohol use. Emotion regulation is a multifaceted construct, composed of both spontaneous and volitional processes. These processes are involved in the generation, appraisal, and modification of emotional states. Volitional emotion regulation is often defined in terms of the ability to down-regulate unpleasant mood states or to up-regulate or maintain positive mood states (Ochsner and Gross 2004). Difficulty regulating emotions "at will" may cause individuals to seek out external means of reducing negative and enhancing positive emotions (Aurora and Klanecky 2016; Beseler et al. 2011; Cooper et al. 1995; Grayson and Nolen-Hoeksema 2005). Emotion regulation difficulties, such as impulse control difficulties and limited emotion regulation strategies, have been associated with greater alcohol consumption in numerous studies (Aurora and Klanecky 2016; Dvorak et al. 2014; Klanecky et al. 2015; Radomski and Read 2016). Therefore, if evening chronotypes use alcohol as an emotion regulation strategy, it is plausible that emotion regulation may constitute a critical mechanism underlying the evening chronotype-alcohol consumption association.

Greater eveningness on continuous measures has been associated with emotion regulation difficulties (Azad-Marzabadi and Amiri 2017). Evening chronotypes also report greater use of emotional suppression (i.e., inhibiting the expression of emotion), while morning chronotypes report greater use of cognitive reappraisal (i.e., reinterpreting an emotion-eliciting stimuli in order to change its emotional impact) (Watts and Norbury 2017). Related literature also suggests that evening chronotypes may have less spontaneous or implicit control of emotions. For instance, research has shown that evening chronotypes score lower on trait measures of emotional stability, emotional control, and self-regulation (Cavallera et al. 2014; Ottoni et al. 2012; Owens et al. 2016) and score higher on measures of emotional problems and emotional distress (Gau et al. 2007; Giannotti et al. 2002; Jeong Jeong et al. 2015). Moreover, morning chronotypes have been found to have more protective qualities, such as resilience (defined as the ability to adapt to various situations, psychological states, and physical health conditions), relative to evening chronotypes (Lee et al. 2016). Taken together, the literature suggests that evening chronotypes may employ less adaptive emotion regulation strategies and may have less successful spontaneous or implicit regulation of emotions; however, the majority of studies in this area have used self-report measures which may be subject to demand characteristics and self-perception bias.

Only one study has examined emotion regulation across chronotypes using an objective, measurement. Horne and Norbury (2018) examined neural activation in response to fearful and happy faces and found that evening chronotypes demonstrated significantly greater amygdala activation in response to fearful versus happy faces (Horne and Norbury 2018). The findings of this study suggest that emotion regulation may vary by chronotype at the physiological level. To date, no studies have examined volitional emotion regulation across chronotypes and, more broadly, the use of physiological signals to measure psychological constructs is scarce within the chronotype literature. Activation of the autonomic nervous system (ANS) is the most common physiological index of emotion regulation (Purves et al. 2001; Thayer et al. 2012) and has not been used to examine emotion regulation across chronotype groups.

The current study examined self-report and autonomic physiology as measures of emotional response during a standardized laboratory emotion regulation task (described in detail below). We hypothesized: 1) evening chronotypes would endorse more symptoms of alcohol use disorder; 2) evening chronotypes would demonstrate poorer emotion regulation on measures of autonomic physiology and self-reported affect; and 3) emotion regulation would statistically account for the associations between chronotype and alcohol use disorder symptoms. Finally, self-reported and autonomic measures of emotion regulation appear to be sensitive to insufficient sleep duration (Baum et al. 2014; Franzen et al. 2011; Mezick et al. 2014; Racine et al. 2013); therefore, sleep duration may modulate chronotype differences in emotion regulation. Sleep duration is often curtailed in evening chronotypes (Jafar et al. 2017; Monk and Buysse 2014), especially on non-free days (i.e., work/school days) (Soehner et al. 2011). Therefore, we evaluated sleep duration on non-free days as a moderator of associations between chronotype and emotion regulation. To our knowledge, no studies have examined the moderating influence of sleep duration on non-free days in associations between chronotype and alcohol use or emotion regulation; however, it is possible that associations between eveningness and greater alcohol consumption and/or poorer emotion regulation may only occur within the context of shorter sleep duration. Thus, exploratory moderation analyses were conducted to evaluate the role of habitual sleep duration on non-free days in predicted associations.

Methods

Participants

Eighty-four undergraduate males and females met inclusion/exclusion criteria (i.e., undergraduate student status, between the ages of 18 and 25 y, free from bipolar disorder, post-traumatic stress disorder, severe depression, alcohol dependence, self-reported pregnancy, and self-reported use of medications that affect autonomic physiology: beta-blockers, tricyclics, clozapine or thioridazine). Three participants did not complete the emotion regulation task. Three participants had missing data in outcome variables. All available data were used and sample sizes for autonomic and affective emotion regulation outcomes were 80 and 79, respectively.

Procedure

After signing informed consent, data were collected using the Qualtrics Survey Service (Qualtrics, Provo, UT). Participants recorded sleep-wake times in an online diary for seven days and completed an emotion regulation task within 2 h of their habitual wake-time to standardize time of day while avoiding the artificial inflation of chronotype group differences. This study was carried out in accordance with international guidelines for chronobiology research (Portaluppi et al. 2010).

Measures

Composite scale of morningness (CSM) (Smith et al. 1989)—The CSM is a 13-item measure of chronotype on a continuum from eveningness to morningness, with current suggested cutoff criteria as follows: 26 evening type, 27–41 intermediate type, and 42 morning type (Natale and Alzani 2000). In our sample, 38.3% ($N = 31$) of participants were evening, 56.8% (N = 46) were intermediate, and 4.9% (N = 4) were morning chronotypes. To form comparable groups, CSM scores 26 (N = 31) denoted evening chronotypes and CSM scores > 26 (N = 50) denoted non-evening chronotypes. We present results using both categorical chronotype groups and continuous CSM scores.

The alcohol use disorder identification test (Babor AUDIT: the alcohol use disorders identification test: guidelines for use in primary health care)

The Alcohol Use Disorder Identification Test (AUDIT) is a 10-item questionnaire probing three domains of alcohol use disorders: harmful alcohol use (e.g., consequences of drinking such as blackouts or alcohol-related injuries), hazardous alcohol use (e.g., the frequency and quantity of alcohol consumption), and dependence symptoms (e.g., impaired control over drinking). Higher scores indicate more problematic alcohol use. Scores 20 indicate probable alcohol dependence.

Demographics—Participants reported age, sex, gender, pregnancy, race, ethnicity, and medication use that can affect autonomic functioning. There was concordance between self-reported sex and gender; thus, sex is used throughout and can be considered synonymous with gender in this study.

Seven-day diary—Using the Qualtrics Survey Service (Qualtrics, Provo, UT), participants recorded daily bed and wake times, sleep latency (SL), and minutes spent awake after initial sleep onset (WASO). Habitual sleep duration was measured as the minutes between bed and wake times minus SL and WASO. Each day, participants indicated if they had a "free day", meaning they were able to sleep in if they wanted to, or a "non-free day", meaning they needed to wake up at a specific time in order to meet an obligation such as attending a morning class or going to work.

The 16-item quick inventory of depressive symptomatology (Rush et al. 2003)—The 16-Item Quick Inventory of Depressive Symptomatology (QIDS SR-16) is a self-report measure of depressive symptom severity. Total QIDS SR-16, minus sleep items (i.e., difficulty falling asleep, staying asleep, waking up too early, or sleeping too much), were

controlled for in analyses due to the relevance of depression for alcohol use and emotion regulation.

Laboratory emotion regulation protocol

Participants were scheduled for a laboratory emotion regulation protocol within 2 h of their habitual diary-assessed wake-time. Participants were asked to abstain from drinking alcohol or caffeine and exercising 12 h prior to their testing session and abstain from smoking 4 h prior to their testing session. Compliance was assessed via self-report at the time of testing.

Baseline—Participants viewed a series of colored blocks for 10 min and were asked to count the first color shown. This baseline task has been shown to be effective for washing-out individual differences in physiological arousal prior to lab-based tasks (Jennings et al. 1992).

Emotion regulation task—The emotion regulation task was adapted from widely-used emotion regulation testing paradigms (Greening et al. 2014; Lee et al. 2014; Moutsiana et al. 2014). Participants viewed a series of neutral, negative, and positive images, selected from the International Affective Picture System (IAPS) (Bradley and Lang 2017). In a pseudorandom order, images were presented in 10 blocks, each comprised of 12 positive, 12 negative, *or* 12 neutral images (Figure 1). Each image was preceded by one of three cues: "look", "reframe", or "enhance". Prior to the task, participants were trained on each cue: "look" cued participants to view the image while experiencing their emotions naturally; "reframe" cued participants to reappraise the image's meaning in a more positive way; "enhance" cued participants to increase their positive response to the image by thinking about it in a more personally relevant manner. Participants practiced "reframing" and "enhancing" their emotions out-loud with a study staff member and then again during a computer practice session. The training and practice sessions were not intended to improve participants' emotion regulation abilities but were rather intended to ensure that participants could perform the task correctly.

Using e-Prime software (Psychology Software Tools, Pittsburgh, PA), participants viewed cues for 1500 milliseconds, an image for 6000 milliseconds, and then rated how they felt on a scale ranging from "extremely negative" to "extremely positive" (for example, see Figure 2).

Operationalization of emotion regulation—Emotion regulation was operationalized as the difference between "look" trials and emotion regulation trials (see key in Table 1).

Physiology—High-frequency variability (HF-HRV) and pre-ejection period (PEP) were used as physiological markers of emotion regulation. Spectral power in the high frequency band of HRV (0.15 to 0.40 Hz) can be obtained from short-term recordings (e.g., 1–5 min) (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996; Pinna et al. 2007) and higher HF-HRV is correlated with greater self-reported emotion regulation (Christou-Champi et al. 2015; De Witte et al. 2016; Smith et al. 2011; Volokhov and Demaree 2010; Williams et al. 2015). Greater HF-HRV during the "reframe" or "enhance" blocks relative to the "look" blocks reflected better

emotion regulation. PEP, the time between depolarization of the left ventricular myocardium and the opening of the aortic valve, indicates sympathetic nervous system activation with longer PEPs indicating lower sympathetic activation (Schachinger et al. 2001) and lower emotional reactivity (Clark et al. 2016). Thus, longer PEPs during the "reframe" or "enhance" blocks relative to the "look" blocks reflected better emotion regulation.

HF-HRV and PEP data acquisition and processing.: Data were collected using Mindware Bionex hardware. Simultaneous electrocardiogram (ECG) and impedance cardiogram (ICG) signals were collected. Mindware HRV 3.1 and IMP 3.1 software were used to calculate HF-HRV and PEP values. HF-HRV was derived through automatic detection of R-peaks, visual inspection, and manual correction. Spectral power in the 0.15 Hz to 0.40 Hz range was calculated using fast Fourier transformation of the inter-beat interval. A Hamming window was used to de-trend, center, and taper the inter-beat interval series. Mindware software IMP 3.1 automatically detected the ECG Q point (ventricular depolarization onset) and the dZ/dt B point (opening of aortic valve) to calculate PEP. Ensemble averages produced by the software were manually inspected, and Q and B points were adjusted in < 10% of cases in accordance with established correction methods (Berntson et al. 2004; Lozano et al. 2007).

Statistical analysis

A natural log transformation was used to correct the skewed distribution of PEP. A general linear model was used to compare chronotype group means on AUDIT scores, controlling for age and depressive symptoms (Hypothesis 1). Emotion regulation variables were compared between evening and non-evening chronotypes using a multivariate analysis of covariance (MANCOVA), controlling for age and depressive symptoms (Hypothesis 2). Due to marked sex differences in chronotype, potentially due to higher conscientiousness among females (Rahafar et al. 2017), sex was evaluated as a potential covariate but had no influence on the results and was not included in the analyses. The percentile bootstrapping method (Shrout & Bolger 2002) was used to test the indirect effect of chronotype on alcohol use disorder severity via emotion regulation. Mediation was only tested when statistically significant pathways were identified between chronotype and emotion regulation (Hypothesis 3). In an exploratory fashion, we tested whether the mediation pathway (the effect of chronotype on emotion regulation) was moderated by sleep duration.

Results

Among the 81 participants who completed the study, the average age was 19.63 ± 1.17 y, 67.9% (N = 55) were female, 69.1% (N = 56) were Caucasian, and 97.5% (N = 79) identified as Non-Hispanic or Latino (Table 2). Average sleep duration was 8.12 h ± 70 min on free days and 6.74 h ± 79 min on non-free days. Evening and non-evening chronotypes did not differ in terms of age, sex, race, or screening measures. Sleep duration on non-free (but not free days) was significantly shorter among evening chronotypes (F = 10.555, p = .002). Evening chronotypes had 2 h less sleep on non-free days relative to free days, whereas non-evening chronotypes had 1 h less sleep on non-free days.

Impact of task on emotion regulation

Manipulation checks revealed that emotion regulation successfully altered affective but not autonomic responses to negative and positive stimuli (Table 3). While viewing negative images, self-reported affect was significantly more negative during "look" trials relative to "reframe" trials ($t(78) = -15.274$, $p < .001$) and significantly more positive during "enhance" trials relative to "look" trials ($t(78) = -13.671$, $p < .001$). There were no differences in HF-HRV or PEP between "look" and "reframe" or "look" and "enhance" trials.

Chronotype and alcohol use disorder symptoms

Scores on the AUDIT ranged from 0 to 18 (mean = 5.19 ± 3.83) and were significantly higher among evening chronotypes (Table 1), after controlling for age and depressive symptoms (F(1,77) = 4.399, $p = .039$; Table 4). Scores on the AUDIT were all below the threshold for alcohol use disorder (i.e., AUDIT scores 20).

Chronotype and emotion regulation

Multivariate tests revealed no effect of chronotype on changes in self-reported affect, HF-HRV, and PEP during negative or positive emotion regulation trials (*Pillai's Trace* = 0.51, F(6,67) = 0.599, $p = .730$; Table 5). Emotion regulation was also unrelated to AUDIT scores.

Emotion regulation as a mediator

Given the lack of difference in emotion regulation between evening and non-evening chronotypes, there was no justification to test the mediation model (Baron & Kenny 1986; Zhao et al. 2010).

Exploratory moderation by sleep duration on non-free days

Moderation analyses revealed a significant interaction between sleep duration on non-free days and chronotype on HF-HRV during negative emotion regulation trials (β = 0.365, $p = .039$; Table 6). Specifically, longer sleep duration on non-free days was associated with increases in HF-HRV from "look" to "reframe" trials for non-evening chronotypes but not for evening chronotypes (Figure 3). This interaction was robust to adjustment for age and depressive symptoms (β = 0.369, $p = .05$). Sleep duration on non-free days did not moderate associations between chronotype and any other emotion regulation outcome.

Discussion

The primary goal of the current study was to evaluate emotion regulation as a pathway linking chronotype to alcohol use. Our data supported Hypothesis 1: evening chronotypes endorsed greater symptoms of alcohol use disorder compared to non-evening chronotypes. Hypothesis 2 was not confirmed: chronotype was unrelated to changes in self-reported affect, high frequency HF-HRV, and PEP during negative and positive emotion regulation. However, in the sample as a whole, the emotion regulation task had an effect on self-reported affect but no effect on HF-HRV or PEP. Alternative emotion regulation tasks using different emotion regulation strategies, longer time to practice emotion regulation

strategies, and different emotional stimuli may be needed to observe emotion regulation using physiological measures. Because self-reported affect during the emotion regulation task was subject to demand characteristics, chronotype differences in emotion regulation remain unclear. Finally, given the lack of associations between emotion regulation and either chronotype or alcohol use, we were unable to test our conceptual mediation model. Future studies using alternate experimental designs are needed to evaluate if emotion regulation could be a mechanism linking chronotype and alcohol use.

Numerous studies have shown that cognitive reappraisal strategies are effective for regulating physiology (Christou-Champi et al. 2015; Di Simplicio et al. 2012; Wu et al. 2015); however, other studies have also found effects for self-reported outcomes but not for physiology (Bernat et al. 2011; De Witte et al. 2017; Hampton et al. 2015; Pedersen and Larson 2016). Differences in manipulation success across studies may be due to slight variations in protocol and length of time participants were given to practice emotion regulation strategies. For instance, in one study, one group of participants was given three training sessions on three separate days, prior to the laboratory emotion regulation task (Christou-Champi et al. 2015). Those who participated in training sessions successfully increased heart rate variability while "reappraising" negative images, while those in a control group who received no training, exhibited no change in heart rate variability. In addition, lack of change in autonomic measures may have been due to our choice of emotional stimuli. While the IAPS are highly validated, they have also been criticized for being somewhat outdated (Gruhn and Sharfian 2016). Thus, it is unclear if the lack of change in autonomic measures was due to a lack of emotional arousal or lack of success regulating emotional arousal.

Despite lack of main effects, exploratory analyses revealed a significant interaction between chronotype and sleep duration on non-free days in relation to negative emotion regulation as measured by changes in HF-HRV. Among non-evening chronotypes, longer sleep duration on non-free days was associated with increases in HF-HRV during negative "reframe" trials relative to negative "look" trials, which may reflect dampened emotional arousal while employing the emotion regulation strategy. Consistent with the broader literature, this finding suggests that longer sleep duration may be protective for autonomic regulation of emotion. Short habitual sleep duration has been associated with lower resting HF-HRV (Castro-Diehl et al. 2016), while sleep deprivation has been shown to result in acute decreases in overall heart rate variability (Tobaldini et al. 2013; Virtanen et al. 2015; Zhong et al. 2005). ANS reactivity to stress has also been shown to be sensitive to short sleep duration (Franzen et al. 2011; Mezick et al. 2014). Interestingly, evening chronotypes demonstrated no association between sleep duration on non-free days and change in HF-HRV during the negative emotion regulation task, indicating that longer sleep duration may not be as beneficial for evening chronotypes as non-evening chronotypes. Alternatively, this finding may suggest that non-evening chronotypes are more sensitive to the effects of shorter sleep duration on parasympathetic regulation of emotions. A prospective study of nightly sleep and nightly emotion regulation may allow us to further understand the chronotype differences seen here. Multilevel modeling could then be employed to evaluate interactions between sleep duration and chronotype on emotion regulation at the between-and within-person levels.

In our sample, eveningness was associated with greater alcohol use disorder symptoms but chronotype was unrelated to changes in affective and autonomic variables during emotion regulation. Therefore, we were unable to test our proposed mediation model. Three studies have identified emotion regulation as mediator between belonging to an at-risk group and substance use; however, all used self-report measures of emotion regulation. Khosravani and colleagues showed that difficulty with emotion regulation, as measured by the Difficulties in Emotion Regulation Scale (DERS) (Gratz and Roemer 2004), mediated the association between positive/negative affect and alcohol cravings in a sample of alcoholic adults (Khosravani et al. 2017). Radomski and Read (2016) have also shown that scores on the DERS mediated associations between PTSD and alcohol use (Radomski and Read 2016). Finally, positive affect during a "savor" condition of an emotion regulation task mediated the association between opioid misuse status and current cravings for opioids (Garland et al. 2017). Emotion regulation strategies are not all equivalent and may vary in their relevance to situations and populations. Future studies may seek to test multiple regulatory strategies and dimensions of emotion regulation to fully understand the role of emotion regulation the conceptual model proposed here.

The current study had several limitations worth addressing. Morning chronotypes were under-represented in our sample (n = 4); thus, evening chronotypes were compared to a group composed mostly of intermediate chronotypes. Studies comparing morning and evening chronotype groups have used a variety of approaches to categorizing continuous measures such as the CSM and MEQ (e.g., *a priori* cutoffs, 10th and 90th percentiles, 20th and 80th percentiles, tertiles, and median splits). Our limited sample size prevented us from obtaining adequate comparison groups and the lack of group differences may have been due to our lack of morning chronotypes. The homogeneity of chronotype in the sample decreases our ability to make strong conclusions regarding chronotype group differences. In spite of this, we were able to find chronotype differences in alcohol use disorder severity while likely being underpowered to detect chronotype differences in emotion regulation. In addition, the current study was limited by the lack of effect emotion regulation had on autonomic physiology. Interestingly, previous studies using highly similar, single-session protocols have shown that autonomic activity (i.e., HF-HRV) is sensitive to both negatively and positively rated IAPS images (Garland et al. 2017). Despite this, more emotionally salient images that are consistent with modern standards or film clips that may better approximate real-life images may be necessary to evoke acute changes in PNS and SNS activation and fully assess emotion regulation across chronotype. Finally, no participants met the threshold for alcohol use disorder, and a lack of individuals on the extreme end of the alcohol use disorder spectrum may be another reason for the lack of conclusive results. Despite this, to our knowledge our results are consistent with the vast majority of studies in this area, with the exception of only one study (Nowakowska-Domagala et al. 2016).

Our study also had several notable strengths. This is the first experimental study to examine volitional emotion regulation in relation to chronotype. The current study extends the literature by demonstrating that chronotypes do not differ in affective or autonomic measures when asked to regulate emotional responses to visual stimuli. While numerous studies have demonstrated an association between chronotype and alcohol use, few studies have tested moderators or mediators of this association. Here, we showed that emotion regulation, as

operationalized in the current study, was unrelated to alcohol use disorder severity and, therefore, could not mediate the chronotype-alcohol use association. Future studies may investigate other strategies for regulating emotions, such as acceptance or distraction. Future studies should also systematically investigate our exploratory finding that longer sleep duration may be protective for negative emotion regulation among non-evening chronotypes.

The current study has implications for public health given the predominance of an evening-oriented culture in colleges and universities and the greater endorsement of alcohol use disorder symptoms among evening chronotypes. However, due to some limitations, including our small sample size, the role of emotion regulation as a potential mechanism underlying the chronotype-alcohol use association is still unclear. Further work using stronger more impactful stimuli to elicit positive and negative emotions and larger study samples are needed to evaluate if emotion regulation is compromised in evening chronotypes and if emotion regulation contributes to the increased risk for alcohol use disorder among evening chronotypes.

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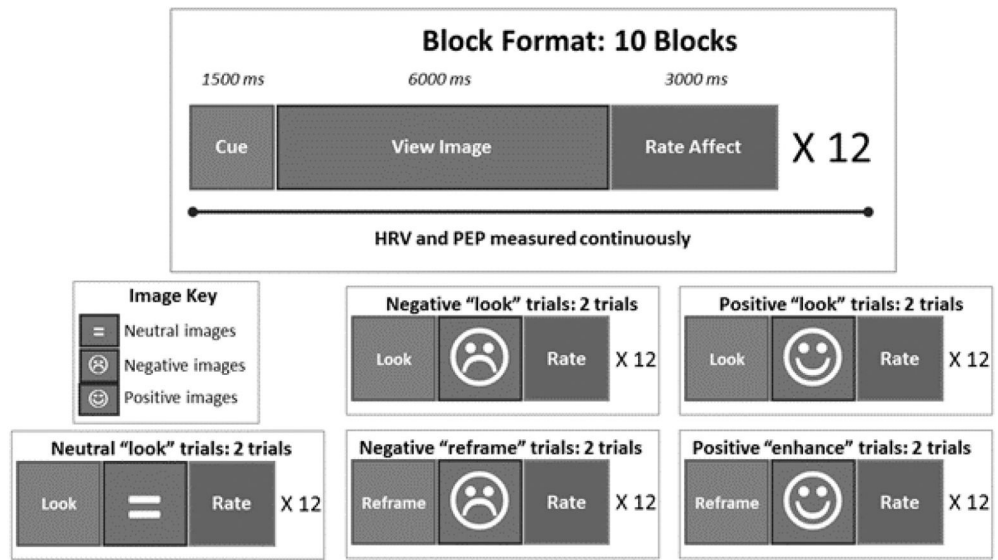
Figure 1.
Emotion regulation task.
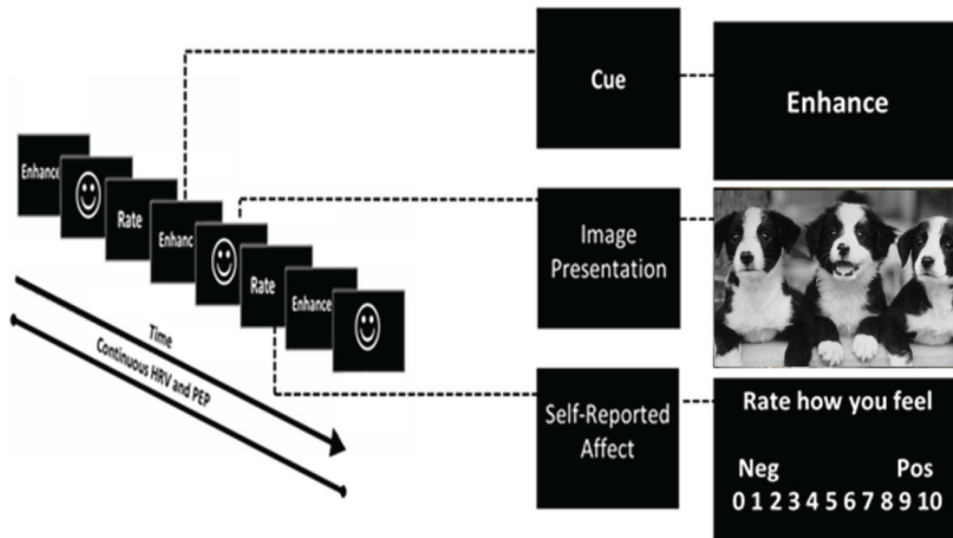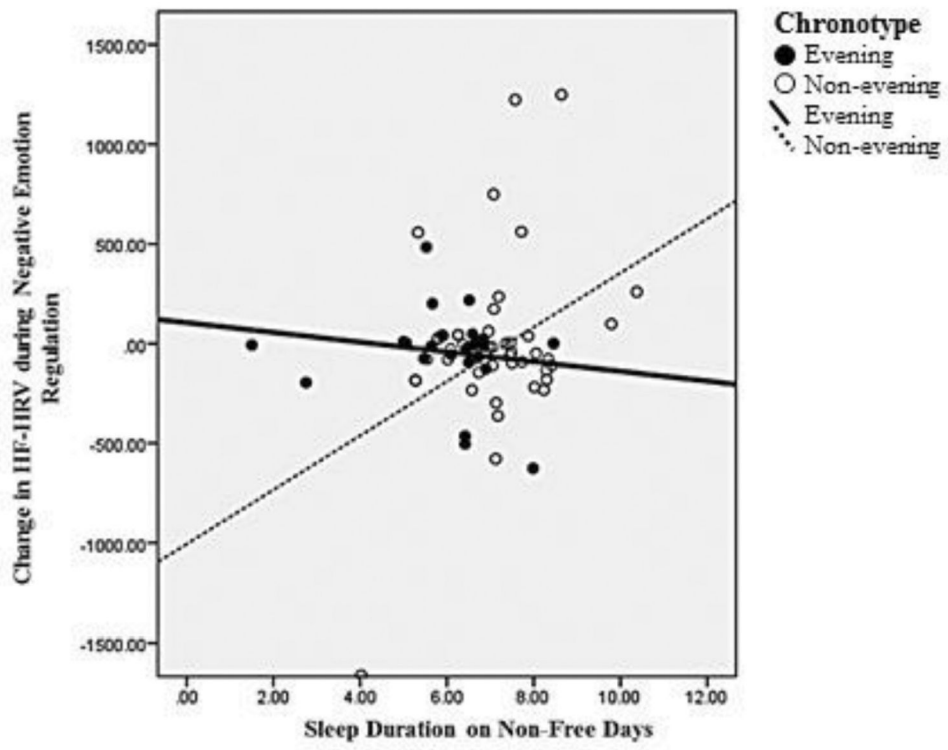
Figure 2.
Slide presentation.

Figure 3.
Sleep duration by chronotype interaction.

Table 1.

Emotion regulation variable key.

Type of Emotion Regulation	Outcome	Calculation		Interpretation
Negative				
	Self-Report Affect	Affect "Reframe"	Affect "Look"	Greater values = more positive affect when regulating negative emotion
	HF-HRV	HRV "Reframe"	HRV "Look"	Greater values = increased HF-HRV when regulating negative emotion
	PEP	PEP "Reframe"	PEP "Look"	Greater values = increased PEP when regulating negative emotion
Positive				
	Self-Report Affect	Affect "Enhance"	Affect "Look"	Greater values = more positive affect when regulating positive emotion
	HF-HRV	HRV "Enhance"	HRV "Look"	Greater values = increased HF-HRV when regulating positive emotion
	PEP	PEP "Enhance"	PEP "Look"	Greater values = increased PEP when regulating positive emotion

Table 2.

Descriptive characteristics.

	Total N = 81	Evening Chronotypes N = 30	Non-Evening Chronotypes N = 51	Sig
Demographics				
Age [a]	19.63 ± 1.17	19.65 ± 1.25	19.62 ± 1.12	.926
Sex, Female [b]	55 (67.9%)	21 (67.7%)	34 (61.8%)	.981
Race White [b]	56 (69.1%)	19 (61.3%)	37 (74.0%)	.682
Black [b]	11 (13.6%)	5 (16.1%)	6 (12.0%)	
Asian [b]	10 (12.3%)	5 (16.1%)	5 (10.0%)	
Other [b]	4 (4.9%)	2 (6.5%)	2 (4.0%)	
Sleep				
SMP Free [a]	6:04 am ± 95 min	7:02 am ± 83 min	5:29 am ± 85 min	<0.001
SMP NonFree [a]	4:53 am ± 62 min	5:24 am ± 53 min	4:34 am ± 61 min	<0.001
TST Free [a]	8.12 hrs ± 70 min	8.19 hrs ± 65 min	8.09 hrs ± 73 min	0.762
TST NonFree [a]	6.74 hrs ± 79 min	6.15 hrs ± 82 min	7.10 hrs ± 70 min	0.002
Alcohol Use Severity				
AUDIT [a]	5.19 ± 3.83	6.35 ± 4.05	4.46 ± 3.54	0.029
Psychological				
IDS [a]	13.49 ± 2.24	13.73 ± 2.41	13.34 ± 2.15	0.451

[a]
means ± standard deviation

[b]
N(%)

SMP = sleep midpoint; TST = total sleep time; AUDIT = Alcohol Use Disorder Identification Test; IDS = Inventory of Depressive Symptoms.

Table 3.

Impact of task on emotion regulation.

	Negative Images "Look" versus "Reframe"		Positive Images "Look" versus "Enhance"	
	t	**sig**	**t**	**sig**
SRA	−15.274	<0.001	−13.671	<0.001
HF-HRV	1.187	0.239	0.809	0.421
PEP	1.832	0.071	−0.875	0.385

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period.

Table 4.

Chronotype predicting alcohol use disorder symptoms.

		AUDIT Scores Regressed on CSM Groups				AUDIT Scores Regressed on Continuous CSM Scores			
		β		R²		β		R²	
Step 1	Age	.025		.023		.025		.023	
	Depression	.150				.150			
Step 2	Chronotype	−.232	*	.054	*	−.281	*	.079	*

AUDIT = Alcohol Use Disorder Identification Test; CSM = Composite Scale of Morningness

*
p < 0.05.

Table 5.

Chronotype and emotion regulation.

	Negative Emotion Regulation ("reframe")						Positive Emotion Regulation ("enhance")					
	SRA		HF-HRV		PEP		SRA		HF-HRV		PEP	
	F	sig	F	sig	F	sig	F	sig	F	sig	F	sig
Categorical[1]												
Univariate	0.173	0.679	0.239	0.626	0.914	0.342	0.283	0.597	0.998	0.321	0.000	0.991
Adjusted*	0.180	0.673	0.203	0.654	1.156	0.286	0.206	0.651	1.055	0.308	0.030	0.863
Continuous[2]												
Univariate	0.009	0.923	0.062	0.803	1.445	0.233	1.915	0.171	1.050	0.309	0.061	0.806
Adjusted*	0.010	0.920	0.054	0.817	1.620	0.207	1.704	0.196	1.067	0.305	0.151	0.699

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

*
Adjusted for age and depressive symptoms

[1]
evening chronotypes compared to non-evening chronotypes

[2]
predicted by continuous Composite Scale of Morningness scores.

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Table 6.

Interactions between sleep duration on non-free days and chronotype predicting emotion regulation.

| | Negative Emotion Regulation ("reframe") | | | | | | Positive Emotion Regulation ("enhance") | | | | | |
| | SRA | | HF-HRV | | PEP | | SRA | | HF-HRV | | PEP | |
	β	sig	β	sig	β	sig	β	sig	β	sig	β	sig
Chronotype × Sleep Duration Non-Free	−0.272	0.126	**0.367**	**0.039**	0.215	0.240	−0.062	0.729	−0.023	0.899	−0.134	0.472
Adjusted for Age and Depressive Symptoms	−0.280	0.128	**0.369**	**0.050**	0.171	0.371	−0.077	0.676	0.015	0.938	−0.063	0.742

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; significant results are in bold.