Impulsivity and heart rate variability before and after mood manipulationin individuals with family history of alcohol abuse

A Senior Honors Thesis

Presented in partial fulfillment of the requirements for graduation *with honors research distinction* in psychology in the undergraduate colleges of The Ohio State University

by

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May 2014

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Abstract

Previous research has shown that addictive behaviors are associated with heart rate variability (HRV) at rest, a physiological marker of self-regulatory ability. A number of studies have shown a link between low HRV and low impulse control, particularly in children. As addiction and HRV are both highly heritable, and impulsivity has been implicated in the manifestation and progression of addiction, there is an impetus to study both HRV and impulsive behaviors in family members of substance abusers. Further, mood dysregulation has been implicated in increases in behavioral impulsivity, as well as in relapse in substance abusing populations. The current study examined the relationship among HRV, impulsivity, and mood dysregulation among individuals with and without a family history of alcohol abuse. Fifty-eight undergraduate students were recruited and identified as either having a family history of problem drinking or not, using the Family Tree Questionnaire (FTQ). Participants completed self-report measures of impulsive behaviors and current alcohol use. To induce mood dysregulation, participants were randomized to view either a neutral valence image set or a negative valence image from the International Affective Picture System (IAPS). Finally, participants completed the Stop-Signal Task, a tool used to assess motor response control. HRV was collected continuously throughout the study using an electrocardiogram. Results showed that those with a family history of problem drinking self-reported more impulsive behaviors and tended to show lower levels of HRV at rest relative to the control group. There was no effect of family history, mood manipulation, or HRV on performance on the Stop-Signal task, suggesting that self-report and behavioral measures of impulsive behaviors may capture different elements of the construct. These data assist in better understating the familiality of behaviors, such as impulsivity, which could be linked to the initiation of drug use and the progression to addiction.

Acknowledgements

I would like to extend my gratitude to Dr. Thayer for the opportunity to work as a research assistant in the Emotions and Quantitative Psychophysiology Laboratory. I would like to thank Brandon Gillie for his countless hours spent helping me develop the studyand analyze the data. Without his critical role as a sounding board for my ideas and his sage and honest advice, this project would not have taken shape. A special thanks to Dixie Hu and DeWayne Williams for their support and battery of fresh ideas. Finally, thanks to my friends and family for their understanding and unwavering support of my work.

Introduction

Numerous studies have suggested relationships between physiological changes in autonomic nervous system functioning and emotional and behavioral psychopathology. Of particular interest to many researchers is the balance between parasympathetic and sympathetic activity that comprises the autonomic nervous system.The sympathetic branch is responsible for "the fight or flight response" in which heart rate and blood pressure increase. Parasympathetic activity, which is conveyed via the vagus nerve, is responsible for relaxation and restoration in which heart rate and blood pressure decrease (Bernston et al., 1994). The body works most effectively when there is high parasympathetic activity (Thayer & Sternberg, 2006). One way to assess the functional capacity of the parasympathetic nervous system is by measuring heart rate variability (HRV). HRV represents the beat-to-beat changes in heart rate that largely result from the tonic, inhibitory influence of the parasympathetic nervous system on the heart. Because the prefrontal cortex exerts control over parasympathetic outflow, vagally-mediated HRV serves as an index of frontal lobe activity and an individual's capacity for self-regulation and executive function (Thayer & Lane, 2009; Appelhans & Leuken, 2006). In addition, there are individual differences in HRV that can be observed at rest. Thayer and Lane (2009) reviewed a number of studies demonstrating that individuals with low resting levels of HRV show deficits in emotion, cognitive, and physiological regulation. The authors suggest that deficits in self-regulation result from the breakdown of inhibitory neural processes. Although HRV can be observed at rest, it is also important to assess change in HRV in response to the environment. For example, when encountering a stressful or emotionally salient event or experience, heart rate variability decreases, and decreased tonic heart rate variability is associated with a myriad of negative psychological outcomes, including anxiety and depression (Gorman & Sloan, 2000).

Addictive behaviors, including smoking, are also associated with lower levels of HRV at rest. For example, heavy smokers show lower acute HRV after postural changes known to affect HRV, as well as lower tonic heart rate compared to healthy controls (Hayano et al., 1990). These findings suggest that heavy smoking decreases vagal control in the long-term (Hayano et al., 1990). Another study investigated the relationship between alcohol use and tonic levels of HRV. Relative to non-alcoholic controls, alcohol abusers show lower levels of HRV at rest (Ingaldsson et al., 2003). Moreover, when exposed to alcohol related cues, those undergoing treatment for alcohol addictions showed higher average levels of HRV than non-alcohol controls, indicating that inhibitory processes were at work in suppressing thoughts about alcohol within the abusers (Ingaldsson et al., 2003). Taken together, these results suggest that those with various forms of addiction may be characterized both by low resting levels of HRV and differential adaptive changes in phasic HRV relative to controls.

One major characteristic of addiction is the tendency to engage in impulsive behaviors. Impulsivity is often defined as a lack of behavioral, cognitive, or emotional inhibition, and is further characterized by four personality facets: urgency, lack of premeditation, lack of perseverance, and sensation seeking (Whiteside & Lynam, 2001). It can be measured through self-report, observation, or behavioral performance tasks. Because HRV has been proposed as an index of inhibitory activity in the prefrontal cortex, a brain region associated with self-regulatory activity, a number of studies have investigated the relationship between individual differences in HRV and the tendency to engage in impulsive behaviors. In two studies of children with attention deficit hyperactivity disorder, lower impulse control was found to be correlated with lower respiratory sinus arrhythmia (RSA), a term used interchangeably with HRV (Raine & Jones, 1987; Beauchaine et al., 2001). In

another study of young children demonstrating aggressive behaviors, low RSA was associated with lower levels of impulse control and greater parental reporting of high-risk behaviors (Calkins & Dedmon, 2000). Further, one study used a performance-basedmeasure commonly used to evaluate impulsive behavior, the continuous performance task (CPT), and found that individuals with higher HRV showed less impulsivity on this task than the low HRV group, as demonstrated though quicker reaction time, fewer errors, and more correct responses (Allen, Matthews, & Kenyon, 2000).

Several studies have evaluated the role of impulsivity and cognitive inflexibility in individuals with specific addictions. Using an intra-dimension/extra-dimension (IDED) set-shift task, in which participants shift from a learned rule to a new rule in response to a cue, pathological gamblers displayed less cognitive flexibility and response inhibition than at-risk and no risk gamblers (Odlaug, 2011). This study provided evidence that cognitive flexibility and response inhibition, two vital components of impulse control, mediate the association between impulsivity and addiction. Other studies have examined the association between impulsivity and particular addictive behaviors such as problematic drinking. Henges & Marczinski (2012) used self-report impulsivity measures and a cued "go/no-go" reaction time test, a direct test of an individual's impulsivity, to predict drinking behavior in undergraduates. Both the self-report impulsivity scale and the direct measure of impulsivity predicted binge-drinking within the past month (Henges & Marczinski, 2012). These results suggest that both self-report and direct measures of impulsivity predict at-risk drinking behaviors (Henges & Marczinski, 2012). Previous research has also found that impulsivity can be manipulated to produce different automatic associations. In one study, Houben and colleagues (2011) used an adaptation of the "go/no-go" reaction test, a commonly used motor response task that assess impulsivity, to evaluate this construct in undergraduates with heavy

alcohol use. Participants were exposed to either "beer/no-go" cues signaling them not to respond, or "beer-go" cues, signaling that a response was required. Those in the "beer/no-go" condition reported a more negative attitude about alcohol and decreased alcohol consumption over the following week, while individuals in the "beer/go" condition experienced a non-significant increase in positive feelings towards alcohol and a significant increase in alcohol consumption (Houben et al., 2011). This study indicates that alcohol consumption and other addictive behaviors can be manipulated by changing implicit attitudes.

Researchers have recently begun to study whether mood dysregulation acts as a moderator of the link between impulsivity and addictive behaviors. In this regard, experimental paradigms have been used to manipulate state affect and observe its effects on behavioral control. For instance, in a study that was non-specific to addiction, researchers used a mood induction task and evaluated impulsivity levels in individuals with anti-social and borderline personality disorders, two disorders also associated with impulse control difficulties (Sprague & Verona, 2010). In this study, individuals were randomized to receive either negatively emotionally salient words, such as "abandon," or emotionally neutral words, such as "lamp." After the priming with either negative or neutral words, the participants' reaction times were tested on an RT task, in which slowed reaction timing indicated impaired behavioral responses. The study found an effect for the emotionally salient negative words in an acute format, such that individuals had increased impulsivity directly after priming with negative cues, though this impulsivity did not persist over a long period of time (Sprague & Verona, 2010). The results of this study suggest that impulsivity is impacted by an individual's mood state, and impulsive behavior is more likely to be observed after the induction of a negative mood. Others have examined the joint influence of

negative mood and self-regulatory ability (as indexed by levels of HRV at rest) on response initiation and inhibition. Findings show that individuals with lower HRV at baseline are more susceptible to the effects of negative mood stimuliand show greater lack of impulse control after mood manipulation (Kryptos et al., 2011).

Additional studies have explored the direct effects for negative mood on relapse. In one study exploring effects of alcoholic stimuli and negative mood in abstaining alcoholics, individuals in a treatment facility underwent negative mood induction, some in combination with exposure to alcoholic stimuli. Both the alcoholic stimuli and the negative affect imagery additively increased self-reported desired to drink. Time to relapse could be predicted by reported urge to drink assessed in the condition combining negative mood induction and alcoholic stimuli presentation (Cooney et al., 1997). In a prospective study of self-reported retrospective mood ratings and factors influencing relapse, individuals most frequently reported negative mood state to be the precipitant for relapse, especially in cases of major relapse (Hodgins, el-Guebaly, & Armstrong, 2012).

Substance abuse, HRV, and impulsivity are all constructs with a high degree of genetic heritability. In a study exploring the genetic influences on variance in HRV, researchers found that genetics explained between 32% and 48% of the variance in RMSSD, and heritability ranged from 40% to 48% for ambulatory RMSSD (Kupper et al., 2004). Substance abuse and genetics have been explored in tandem extensively, with several genes implicated in substance abuse generally, and alcohol addiction specifically, including *TPH1*, *SERT*, *MAOA,* and dopamine receptors D3 and D4 (Kreek et al., 2005). These genes have also been found to be highly correlated with impulsivity (Kreek et al., 2005; Kreek, Nielsen, & LaForge, 2004).Further, low serotonin metabolism has been found to be correlated with impulsive behavior, as well as with increased risk of impulsivity in first-degree relatives

(Coccaro et al., 1994). Serotonin neurons project widely throughout the brain from the raphe nucleus, including to the hippocampus, amygdala, and prefrontal cortex, the area most likely impaired in those with impulse control deficits (Kreek et al., 2005). In sum, evidence suggests that some individuals' genetic dispositions may influence resting levels of HRV and make them more vulnerable to developing addictive and impulsive behaviors.

Although individual differences in heart rate variability, impulsivity, and mood dysregulation each seem to play a significant role in addiction and alcoholism, researchers have yet to investigate the relationships among these factors in a comprehensive manner. Moreover, understanding how these components interrelate among individuals who are at greater risk of developing addiction may lead to improved prevention and intervention efforts. Therefore, the purpose of the current study was to evaluate relationshipsamong heart rate variability, impulsivity, and mood dysregulation in individuals who self-report having a first-degree relative who is a problem drinker. We hypothesized that the relatives of problem drinkers would both self-report higher levels of impulsivity than controls, and would demonstrate higher levels of impulsivity on a performance-based behavioral measure. We also hypothesized that relatives of a problem drinker would have lower tonic HRV at baseline than controls. Individuals exposed to negative valence emotional stimuli were expected to demonstrate higher levels of impulsivity on the performance-based measure of impulsiveness and to have lower HRV at task when compared to those exposed to neutral valence emotional stimuli. Relatives of problem drinkers who were exposed to the negative valence emotional stimuli were hypothesized to demonstrate the highest levels of behavioral impulsivity on the performance-based impulse control task, and to have the lowest HRV at task, in comparison with the other group-condition pairs.

Method

Participants

Undergraduate students at The Ohio State University enrolled in introductory psychology courses were prescreened on a measure of alcohol use in first-degree relatives (parents and siblings) through the Research Experience Program (REP). Participants were pre-screened using the Family Tree Questionnaire (FTQ). Participants who identified at least one family member as a "probable or definite problem drinker" were invited to participate in the study; this group will be further referred to as the experimental group. Individuals who reported no family history of alcohol abuse were also invited; this group will be referred to as the control group. Participants were told that the study explored correlations between impulsivity and mood dysregulation, and that the research could be useful in evaluating links between impulsivity and addiction. Further, the study was described as exploring the relationship between cardiovascular functioning, mood alteration, and impulsiveness, using a measure of impulse control. Individuals with an allergy to the electrode adhesive were excluded. A total of 61 participants were enrolled, ranging in age from 18 to 23 years of age. Three participants failed to complete all portions of the study due to technical difficulty or withdrawal, leaving a final sample of 58 for analyses. The average age of the participants was 18.8 years with a standard deviation of 1.364.The sample was composed of 44 females (72.1%) and 17 males (27.9%). The sample consisted of 49 Caucasians, 5 African Americans, 2 Hispanics, 4 Asians, and 1 individual identifying as "Other." As compensation, participants received one hour of research credit in partial fulfillment of a course requirement.

Research Design

We utilized a 2x2 between-groups design to examine the effects of experimental condition (negative valence image vs. neutral valence images) and familial drinking status group (no family members identified as problem drinkers vs. one or more family members identified as problem drinkers) on our dependent variables. The breakdown of number of individuals in each group and condition is displayed in Table 1. The dependent variables include performance on the Stop-Signal Task and HRV measured at baseline and task periods. All questionnaires were self-report.

Measures

Physiological data was collected using a standard three-electrode setup. The electrocardiogram (ECG) signal was sampled at a rate of 1000 Hz using a high pass filter of .5 Hz and was passed through Mindware Technology's BioNex two-slot mainframe (Mindware Technology, Gahanna, OH) to a personal computer. The ECG signal was analyzed offline using Mindware Technology's HRV 2.51 software.This software allows for visual inspection and editing of the ECG signal.Artifact correction was performed for any irregular and ectopic beats. To obtain estimates of HRV, the interbeat interval (IBI) time series was written in a single text file and analyzed using the Kubios HRV analysis package 2.0.We examined the interbeat intervals and removed artifacts using the Kubios HRV analysis software program (Tarvainen et al., 2009). Kubiosproduces values of vagally-mediated (parasympathetic) HRV including root mean square of successive differences (RMSSD), a time-domain measure of HRV. Because values of HRV tend to be skewed, RMSSD was natural log transformed to better approximate a normal distribution. All procedures are in accordance with the recommendations of Task Force of the European

Society of Cardiology and the North American Society of Pacing Electrophysiology (Camm et al., 1996).

The Stop-Signal Task is a computer-based task that assesses motor response control by introducing go-signals and stop-signals to the participant (Verbruggen & Logan, 2008). Using a standard computer keyboard,participants responded to go-signals by pressing a key corresponding with a specific shape stimulus ("Z" for square and "/" for triangle). The stop-signal, an audible beep played over speakers, indicated that the participant should not respond to the shape stimulus displayed on the screen. Each participant completed a practice trial set, followed by three trial setsof 64 responses for which the results were analyzed. The practice trial and three analyzed trails took approximately ten minutes in total to complete, with some variability between subjects depending on reaction time. Three different outcomes were assessed for the Stop-Signal Task. Mean probability of responding (p(r | s)) on stop-signal trials assessed the likelihood of individuals responding on trials in which a stop signal was presented.The second outcome that was assessed was mean-stop-signal delay (SSD), a variable that changed with the performance of each participant on the task, such that the SSD was increased with better performance on the task. The final variable that was assessed, stop-signal reaction time (SSRT), can be found by subtracting the SSD from the finishing time on the task (Verbruggen & Logan, 2008).

The International Affective Pictures System (IAPS) is a series of emotion-salient pictures commonly used to induce a variety of mood states (Lang, Bradley & Cuthbert, 1999). Participants viewed each of the pictures on a standard 36 inch by 20 inch television display. Each participant was randomly assigned (using a random number generator), to view neutral valence images or negative valence images. Both the negative valence set and the neutral valence set contained 36 pictures, each of which was displayed for ten seconds.

Questionnaires

The Family Tree Questionnaire (FTQ) is a short interview used to classify the alcohol use of first-degree relatives (parents and siblings). The questionnaire asked the subject to rate each blood relative (mother, father, up to four brothers, and up to four sisters) using the distinctions, "Never drank," "Social drinker," "Possible problem drinker," "Definite problem drinker," and "Don't know/Don't remember" (Vogel-Sprott et al., 1985).The scale is a valid tool for assessing the incidence of problem drinking in families and demonstrates good test-retest reliability (Vogel-Sprott et al., 1985). The Barratt Impulsiveness Scale (BSI-11), a thirty item questionnaire designed as a self-report measure of impulsive personality traits, consisted of six first-order factors, including attention, motor, self-control, cognitive complexity, perseverance, and cognitive instability impulsiveness, and three second-order factors, including attentional, motor, and non-planning impulsiveness. Each question was assessed on a 4-point Likert scale, with "Never," "Rarely," "Almost Always," and "Always" comprising the four options. The higher an individual scores on the scale, the greater that individual's impulsiveness rating (Reynolds et al., 2006). The BIS-11 is the most commonly used self-report measure in both research and clinical settings for the assessment of impulsivity (Stanford et al., 2009). The Alcohol Use Disorders Identification Test (AUDIT) is a ten question measure assessing personal self-reported alcohol use in the last year using a five point Likert scale. The questionnaire assesses frequency of alcohol intake, quantity of intake, and factors associated with alcohol consumption (Bush, et al. 1998). The sensitivity and specificity of this test are comparable, if not superior, to other self-report measures, and has excellent test-retest reliability and internal consistency (Reinert & Allen, 2006). The Beck Depression Inventory (BDI) assessed the extent of depressive symptoms, ranging from

vegetative symptoms to suicidal ideation; higher scores indicate greater depressive symptoms (Beck et al., 1961). The Positive and Negative Affect Schedule (PANAS) is a twenty-item measure assessing positive affect and negative affect on a five-point Likert scale (Watson et al. 1988). Participants completed both the state and trait versions of this scale, each of which asks the same questions, though the trait version assesses how individuals feel on average, while the state version assesses how individuals feel at that moment. The Effortful Control Scale (ECS) consists of twenty-four self-report items that assess how much an item describes the individual "most of the time" on a five-point Likert scale (Lonigan & Phillips, 2001). The scale assesses both Persistence/Low Distractibility and Impulsivity. All questionnaires are included in Appendix A.

Procedure

Informed consent was obtained from each participant upon entering the research lab. Demographic information was collected for each participant, after which the subject was connected to a three lead electrocardiogram. Heart rate variability (HRV) data was collected for the duration of the participant's time in the lab. First, participants were asked to sit still for a five-minute baseline period during which resting HRV levels were collected. Next, participants were asked to complete a series of six self-report questionnaires, including the Barratt Impulsiveness Scale (BSI-11), the Alcohol Use Disorders Identification Test (AUDIT), both the state and trait versions of the Positive and Negative Affect Schedule (PANAS), and the Effortful Control Scale (ECS). Next, participants viewed either the negative or neutral IAPS image set based on their randomization. This portion of the study took six minutes for participants in both conditions. Following the IAPS, participants completed the state version of the PANAS again as a manipulation check. Finally,

participants completed the practice and three actual trials of the Stop-Signal Task. Following the Sop-Signal Task, participants were detached from the electrocardiogram machine and debriefed.

Results

Manipulation check

To assess whether the IAPS manipulation resulted in the expected changes in positive and negative affect, assessed via the PANAS, we conducted two separate repeated measure analyses of variance (ANOVA) with a within subject factor of time (pre to post) and a between subject factor of condition (negative vs. neutral induction). Analyses showed a significant main effect of time $F(1, 56) = 22.14$, $p < .001$ and a significant time by condition interaction$F(1, 56) = 15.68$, $p < .001$ for negative affect. There was a significant effect of time on positive affect $F(1, 56) = 26.89$, $p < .001$, but no significant time by condition interaction $F(1, 56) = .84$, $p = .36$. Results of the repeated measures ANOVA are illustrated in Figure 1 and Figure 2. Consistent with hypotheses, those in the negative mood condition showed greater increases in negative affect than those in the neutral condition. Thus, the mood manipulation was successful.

Preliminary analyses

Table 2 presents the correlations among the independent variables (familial drinking status, experimental condition) and the dependent variables, including the different outcome measures for the Stop Signal Task, log transformed RMSSD at baseline, and summed scores on the AUDIT, BIS-11, BDI, and ECS. Greater symptoms of depression as reported on the BDI were positively correlated with impulsivity as reported on the BIS-11 ($r(58) = .29$,

p<.05). Furthermore, higher levels of effortful control as measured by the ECS were associated with less self-reported impulsivity (r(58) = -.62, p< .001). Interestingly, mean stop signal delay (SSD) was negatively, though not significantly correlated, with RMSSD, indicating that higher levels of HRV were associated with poorer performance on the stop-signal task. No other outcomes approached statistical significance.

Next, we examined whether those with a family history of alcohol abuse differed from controls on self-reported measures of impulsivity and HRV at rest. Two independent samples t-tests were conducted to examine differences between the groups. Results showed that those with a family history of alcohol abuse reported significantly higher levels of impulsive behaviors (M = 67.00, SD = 9.69) compared to those without a family history of alcohol abuse (M = 57.83, SD = 8.74;t(56) = 3.74, p< .001). Another t-test indicated that the two groups did not significantly differ in RMSSD at baseline (t(56) = 1.28 p = .11), however, the pattern of the results was in the expected direction as individuals with a family history of alcohol abuse tended to display lower HRV on average than individuals in the control condition.

Effects of mood induction and family history on change in HRV

To examine the effect of the mood induction procedure on change in HRV, we conducted an ANOVA with a repeated factor of HRV (measured during baseline, mood induction, and the stop-signal task) and between subjects factor of experimental condition (negative vs. neutral) and family history of alcohol use (family history of problem drinkers vs. no history). Results showed no significant within-subject effect of HRV F(2, 108) = 1.69, p = .18 nor significant effects of HRV x experimental condition F(2, 108) = 2.14, p = .12, HRV x family history F(2, 108) = 1.80, p = .17, or three way interaction F(2, 108) = .83, p =

.43. Contrast analyses conducted within the different effects were not statistically significant (all p values > .17).

Effects of HRV, mood induction, and family history on stop-signal task performance

We also investigated how individual differences in HRV, mood induction, and family history of alcohol predicted performance on the outcome measures of the stop-signal task (p(r | s), SSD, and SSRT). A multivariate analysis of variance (MANOVA) was used to assess the main effects of the independent variables, two-way interactions, and the higher-order three-way interaction on the three dependent variables. In order to examine the effect of RMSSD, the variable was dichotomized on the basis of a median split. For each of the dependent variables, there were no significant main effects of RMSSD, experimental group, or family history of alcohol use on any dependent variable (all *p* values > .27). There were no significant two-way interactions among the independent variables (all *p* values > .42) and the three way-interaction was not significant for any task outcome (all *p* values > .68).

Discussion

The current study sought to investigate the associations among HRV, impulsivity, and mood dysregulation among individuals with and without a family history of alcohol abuse. Our results showed that those with afamily history of problem drinking behaviors self-reported higher levels of impulsiveness than healthy controls. Furthermore, we observed that the two groups tended to differ in resting levels of HRV; those reporting a family history of problem drinking tended to show lower levels of HRV at rest relative to the controls. Although this pattern of results was not statistically significant, it implies that individuals more vulnerable to developing addictionmay be characterized by disruptions in physiological

markers of self-regulation. In addition, we did not find statistically significant differences between those with a history of family of alcohol use and those without such a history in terms of performance on the stop-signal task. Although the mood manipulation increased negative affect, it did not significantly impact task performance or alter levels of HRV. Lastly, there was no effect of resting levels of HRV on task performance.

Consistent with hypotheses, the results demonstrated that individuals reporting a family history of problem drinking behaviors endorsed greater impulsivity than those without a family history of problem drinking behaviors. These findings are important, as they are consistent with the body of previous literature suggesting that impulsivity is heritable in first-degree relatives of alcoholics. Furthermore, the trend toward significance between low HRV at baseline and individuals reporting family history of problem drinking is consistent with the hypotheses. This trend is interesting and, with a larger sample size, could indicate familiality of low HRV in first-degree relatives of problem drinkers. This result, taken in conjunction with the higher levels of impulsivity reported by first-degree relatives of problem drinkers, could provide meaningful insight into potential etiology for the disease.

The data suggests that there was no difference in impulsivity between the experimental group and the control group on the Stop-Signal Task, despite the significant noted relationship between self-report impulsivity and group. Interestingly, however, there was a correlation between effortful control and self-report of impulsivity, such that individuals self-reporting higher levels of impulsive behaviors also self-reported lower levels of effortful control. These results suggest that, though self-report measures of impulse control are consistent with onto one another, they may not map on to performance-based measures of impulsivity, such as the stop-signal task. This idea is consistent with other findings which have also shown poor convergent validity between behavioral measures of

impulsivity and self-report measures of impulsivity (Reynolds et al., 2006; Duckworth & Kern, 2011). Although it is unclear what accounts for heterogeneity among different measures of impulsivity, using different methodologies will likely provide the most comprehensive view of the impulsivity construct.

The IAPS manipulation produced a significant change in negative mood between the two groups, such that individuals who saw the negative valence images reported a significant increase in negative mood compared to those who viewed the neutral valence images. Although the IAPS manipulation increased negative affect, there was no evidence indicating that this mood change affected impulsivity, assessed via performance on the stop-signal task. Furthermore, the mood manipulation did not produce different effects among those with or without a family history of alcohol use and it did not significantly change over time. Previous studies have found that mood dysregulation impacts impulsivity among individuals with psychopathology, including those with anti-social and borderline personality disorder (Sprague & Verona, 2010). Perhaps the association between mood dysregulation and impulsivity is best seen among individuals with mental disorders, as opposed to a relatively healthy population such as the one used in the current study.

Limitations and Future Directions

In this study, familial problem drinking behavior was self-reported by participants, such that all results were dependent on subjects' assessment of the drinking behaviors of parents and siblings. Though addiction is highly heritable, a better measure of familial problem drinking should be used in future studies to more accurately capture the problem drinking of first-degree relatives. Further, future studies could exclude the individuals

labeled as "probable" problem drinkers and run analyses only using participants who identified a parent or sibling as a "definite" problem drinker.

A major limitation of this study was its small sample size, due largely to issues with recruitment. Future studies should seek to ensure that all condition and group pairs have equal numbers of participants.

Future studies should also seek to collect data on smoking status, exercise level, and exercise within the past 24 hours, such that appropriate exclusions can be made. As each of these factors can influence HRV, results will be more accurate even if these factors could be included as covariates.

Future studies could also use the model for the stop-signal task used by Kryptos et al. (2011), such that the IAPS images would be incorporated into the behavioral impulsivity task. As the current study asked participants to fill out the PANAS State questionnaire between the IAPS and Stop-Signal Task, participants were asked to recognize and quantify their feelings and mood state. Future studies should reduce the time delay between the mood dysregulation and stop-signal task, so as to not directly call attention to the mood state of the participants.

Conclusion

In sum, the purpose of this study was to explore the relationship between familial drinking behaviors, impulsive behaviors, and HRV in relationship to a mood dysregulation event. Results revealed that individuals who self-reported familial problem drinking behaviors reported higher levels of impulsive behaviors and tended to show lower levels of HRV at rest relative to those without a family history of familial problem drinking behaviors. However, there was no relationship between self-report impulsivity and a behavioral measure

of impulsivity. Further, there was no relationship between mood state and impulsive behaviors, nor was there a correlation between HRV and impulsivity. Although a number of results were inconsistent with previous literature, the current study highlights the relative contributions of the multiple measures of impulsivity among individuals at risk for developing addictive behaviors.

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Table 1

Number of study participants by group and condition

	Negative Valence Images	Neutral Valence Images	Total
Experimental Condition	13	11	24
Control Condition	15	22	37
Total	28	33	61

Note. Numbers represent actual counts. "Experimental Condition" refers to participants who identified at least one immediate relative (parent or sibling) as a "probable problem drinker" or a "definite problem drinker." "Control Condition" refers to participants who did not identify any immediate relatives as "probable problem drinkers" or "definite problem drinkers."

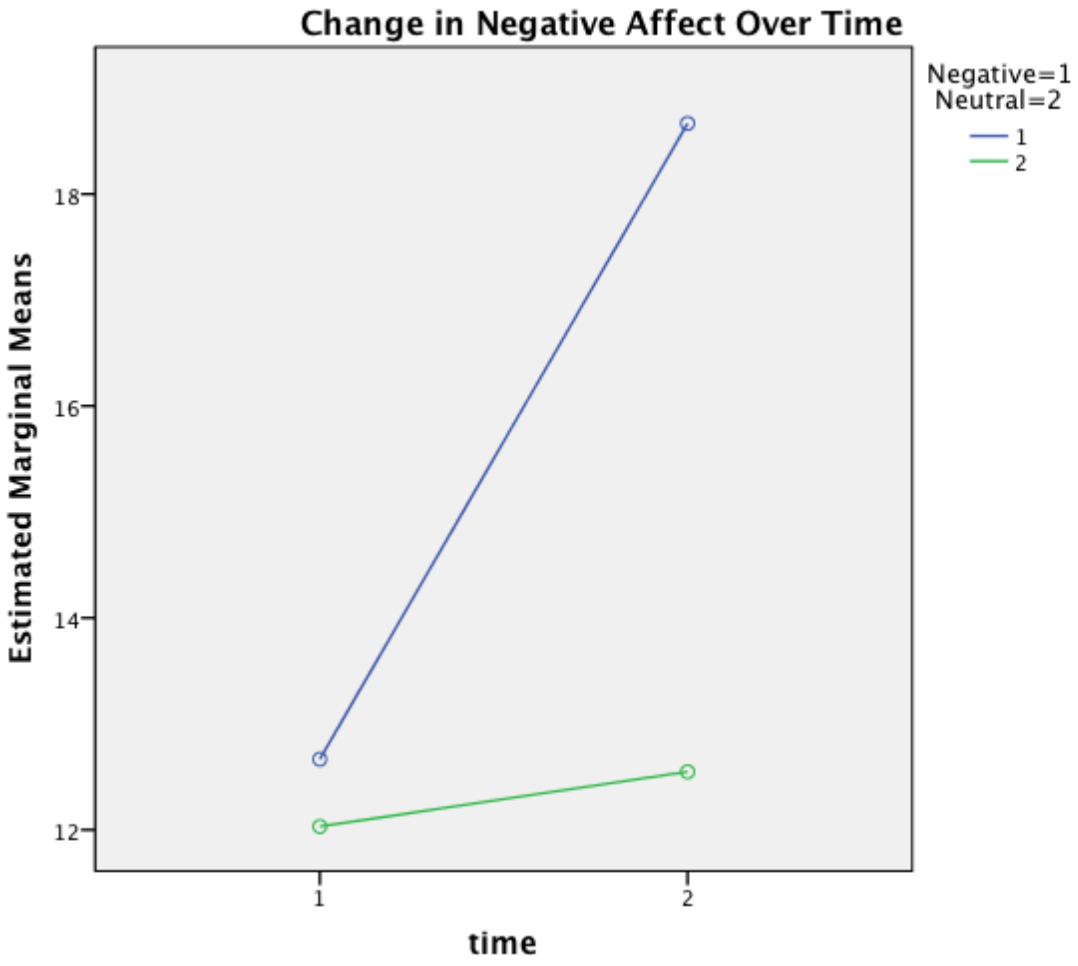
Table 2

Correlations among primary measures

	1	2	3	4	5	6	7	8	9
1. Group	-								
2. Condition	.16	-							
3. RMSSD- HRV	.21	.07	-						
4. P (r | s)	.18	.01	.15	-					
5. SSD	.04	-.04	-.24	-.41**	-				
6. SSRT	-.09	-.14	-.11	.08	-.52**	-			
7. AUDIT Sum	-.17	.09	.01	-.03	-.19	.08	-		
8. BIS-11 Sum	-.45**	-.03	.09	-.001	.04	.00	.36**	-	
9. BDI Sum	-.25	-.06	-.02	-.23	.02	.03	.03	.29*	-
10. ECS Sum	.29	-.05	-.28	.15	-.05	.09	-.34	-.62**	-.21

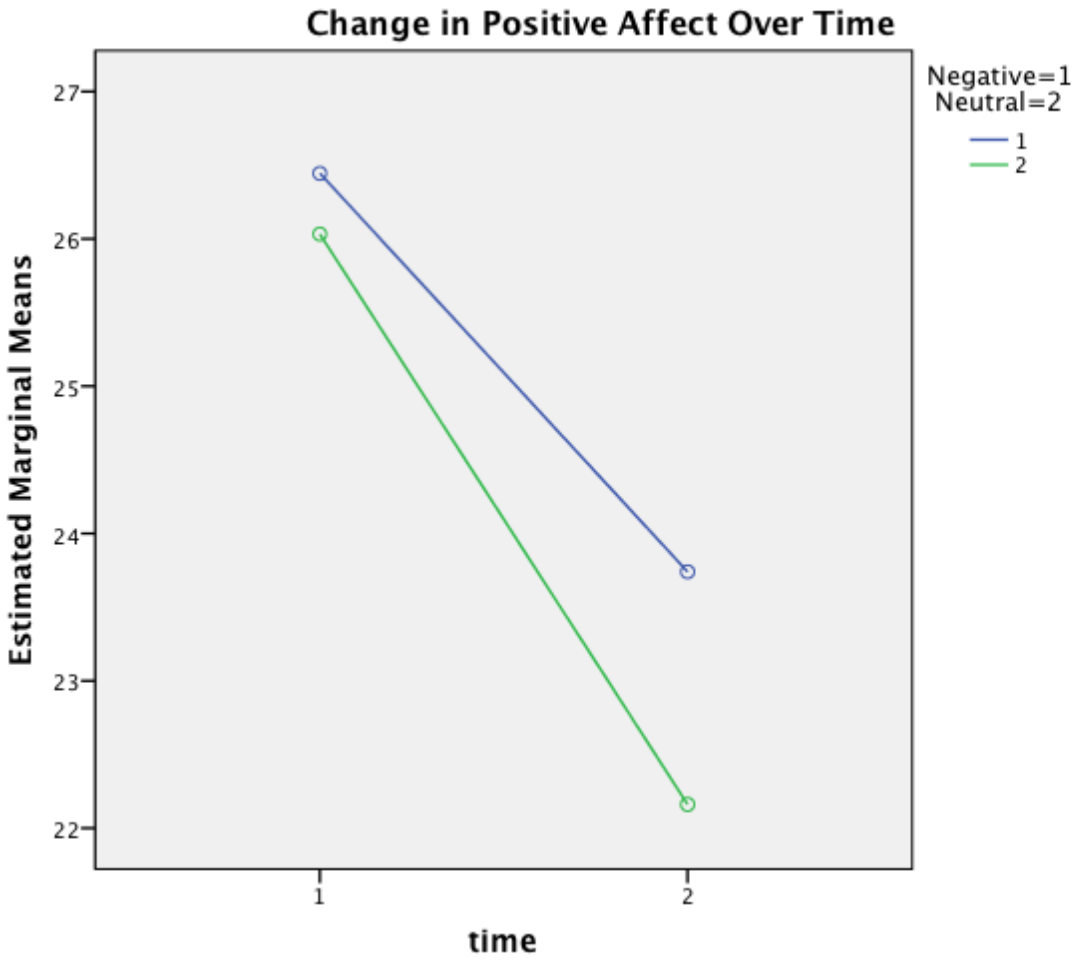
Note. N=61. Group; 1 = experimental; 2 = control; Condition; 1 = negative images; 2 = neutral images.
P (r | s) = mean probability of responding on stop-signal trials; SSD = mean stop-signal delay; SSRT = mean stop-signal reaction time; AUDIT = Alcohol Use Disorders Identification Test; BIS-11 = Barratt Impulsiveness Scale; BDI = Beck Depression Inventory; ECS = Effortful Control Scale
* = Correlation significant at $p < .05$, two-tailed. ** = Correlation significant at $p < .01$, two-tailed.

Figure 1



Note. Figure represents the manipulation check for the International Affective Picture System (IAPS) mood manipulation, as measured by change in negative affect on the Positive and Negative Affect Schedule (PANAS) State self-report questionnaire. The graph reports change in negative mood based off the ten items assessing negative mood in the PANAS State. The questionnaire was completed by participants ten minutes before and directly after the IAPS was viewed. "Negative" indicates that participants were randomized to observed the negative valence images and "neutral" indicates that participants were randomized to observe the neutral valence images.

Figure 2



Note. Figure represents the manipulation check for the International Affective Picture System (IAPS) mood manipulation, as measured by change in negative affect on the Positive and Negative Affect Schedule (PANAS) State self-report questionnaire. The graph reports change in positive mood based off the ten items assessing positive mood in the PANAS State. The questionnaire was completed by participants ten minutes before and directly after the IAPS was viewed. "Negative" indicates that participants were randomized to observed the negative valence images and "neutral" indicates that participants were randomized to observe the neutral valence images.

Appendix A

Questionnaires

The Positive and Negative Affect Schedule (PANAS) State

Instructions: This scale consists of a number of words that describe different feelings and emotions. Read each item and then select the appropriate answer using the corresponding number key. Indicate to what extent you feel this way right now, that is, at the present moment.

1=Very slightly or not at all
2=A little
3=Moderately
4=Quite a bit
5=Extremely

1. Interested
2. Distressed
3. Excited
4. Upset
5. Strong
6. Guilty
7. Scared
8. Hostile
9. Enthusiastic
10. Proud
11. Irritable
12. Alert
13. Ashamed
14. Inspired
15. Nervous
16. Determined
17. Attentive
18. Jittery
19. Active
20. Afraid

The Positive and Negative Affect Schedule (PANAS) Trait

Instructions: This scale consists of a number of words that describe different feelings and emotions. Read each item and then select the appropriate answer using the corresponding number key. Indicate to what extent you generally feel this way, that is, how you feel on the average.

1=Very slightly or not at all
2=A little
3=Moderately
4=Quite a bit
5=Extremely

1. Interested
2. Distressed
3. Excited
4. Upset
5. Strong
6. Guilty
7. Scared
8. Hostile
9. Enthusiastic
10. Proud
11. Irritable
12. Alert
13. Ashamed
14. Inspired
15. Nervous
16. Determined
17. Attentive
18. Jittery
19. Active
20. Afraid

Beck Depression Inventory

Instructions: This questionnaire consists of 20 groups of statements. Please read each group of statements carefully, and then pick out the one statement in each group that best describes the way you have been feeling during the past two weeks, including today. If several statements in the group seem to apply equally well, select the highest number for that group. Select your response using the corresponding number key.

1. Sadness
    - 0=I do not feel sad.
    - 1=I feel sad much of the time.
    - 2=I am sad all the time.
    - 3=I am so sad or unhappy that I can't stand it.
2. Pessimism
    - 0=I am not discouraged about my future.
    - 1=I feel more discouraged about my future than I used to be.
    - 2=I do not expect things to work out for me.
    - 3=I feel my future is hopeless and will only get worse.
3. Past Failure
    - 0=I do not feel like a failure.
    - 1=I have failed more than I should have.
    - 2=As I look back, I see a lot of failures.
    - 3=I feel I am a total failure as a person.
4. Loss of Pleasure
    - 0=I get as much pleasure as I ever did from the things I enjoy.
    - 1=I don't enjoy things as much as I used to.
    - 2=I get very little pleasure from the things I used to enjoy.
    - 3=I can't get any pleasure from the things I used to enjoy.
5. Guilty Feelings
    - 0=I don't feel particularly guilty.
    - 1=I feel guilty over many things I have done or should have done.
    - 2=I feel quite guilty most of the time.
    - 3=I feel guilty all of the time.
6. Punishment Feelings
    - 0=I don't feel I am being punished.
    - 1=I feel I may be punished.
    - 2=I expect to be punished.
    - 3=I feel I am being punished.
7. Self-Dislike
    - 0=I feel the same about myself as ever.
    - 1=I have lost confidence in myself.
    - 2=I am disappointed in myself.
    - 3=I dislike myself.
8. Self-Criticalness
    - 0=I don't criticize or blame myself more than usual.
    - 1=I am more critical of myself than I used to be.
    - 2=I criticize myself for all of my faults.
    - 3=I blame myself for everything bad that happens.

9. Crying
    0=I don't cry anymore than I used to.
    1=I cry more than I used to.
    2=I cry over every little thing.
    3=I feel like crying, but I can't.
10. Agitation
    0=I am no more restless or wound up than usual.
    1=I feel more restless or wound up than usual.
    2=I am so restless or agitated that it's hard to stay still.
    3=I am so restless or agitated that I have to keep moving or doing something.
11. Loss of Interest
    0=I have not lost interest in other people or activities.
    1=I am less interested in other people or things than before.
    2=I have lost most of my interest in other people or things.
    3=It's hard to get interested in anything.
12. Indecisiveness
    0=I make decisions about as well as ever.
    1=I find it more difficult to make decisions than usual.
    2=I have much greater difficulty in making decisions than I used to.
    3=I have trouble making any decisions.
13. Worthlessness
    0=I do not feel I am worthless.
    1=I don't consider myself as worthwhile and useful as I used to.
    2=I feel more worthless as compared to other people.
    3=I feel utterly worthless.
14. Los of Energy
    0=I have as much energy as ever.
    1=I have less energy than I used to have.
    2=I don't have enough energy to do very much.
    3=I don't have enough energy to do anything.
15. Changes in Sleeping Pattern
    0=I have not experienced any change in my sleeping pattern.
    1a=I sleep somewhat more than usual.
    1b=I sleep somewhat less than usual.
    2a=I sleep a lot more than usual.
    2b=I sleep a lot less than usual.
    3a=I sleep most of the day.
    3b=I wake up 1-2 hours early and can't get back to sleep.
16. Irritability
    0=I am no more irritable than usual.
    1=I am more irritable than usual.
    2=I am much more irritable than usual.
    3=I am irritable all the time.
17. Changes in Appetite
    0=I have not experiences any change in my appetite.
    1a=My appetite is somewhat less than usual.
    1b=My appetite is somewhat greater than usual.
    2a=My appetite is much less than before.

2b=My appetite is much greater than usual.
3a=I have no appetite at all.
3b=I crave food all the time.

18. Concentration Difficulty
    0=I can concentrate as well as ever.
    1=I can't concentrate as well as usual.
    2=It's hard to keep my mind on anything for very long.
    3=I find I can't concentrate on anything.
19. Tiredness or Fatigue
    0=I am no more tired or fatigue than usual.
    1=I get more tired or fatigued more easily than usual.
    2=I am too tired or fatigued to do a lot of the things I used to do.
    3=I am too tired or fatigued to do most of the things I used to do.
20. Loss of Interest in Sex
    0=I have not noticed any recent change in my interest in sex.
    1=I am less interested in sex than I used to be.
    2=I am much less interested in sex now.
    3=I have lost interest in sex completely.

Barratt Impulsiveness Scale (BIS-11)

Instructions: People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and select the appropriate response with the corresponding number key. Do not spend too much time on any statement. Answer quickly and honestly.

1=Rarely/Never
2=Occasionally
3=Often
4=Almost always/Always

1. I plan tasks carefully.
2. I do things without thinking.
3. I make-up my mind quickly.
4. I am happy-go-lucky.
5. I don't "pay attention."
6. I have "racing" thoughts.
7. I plan trips well ahead of time.
8. I am self-controlled.
9. I concentrate easily.
10. I save regularly.
11. I "squirm" at plays or lectures.
12. I am a careful thinker.
13. I plan for job security.
14. I say things without thinking.
15. I like to think about complex problems.
16. I change jobs.
17. I act "on impulse."
18. I get easily bored when solving thought problems.
19. I act on the spur of the moment.
20. I am a steady thinker.
21. I change residences.
22. I buy things on impulse.
23. I can only think about one thing at a time.
24. I change hobbies.
25. I spend or charge more than I earn.
26. I often have extraneous thoughts when thinking.
27. I am more interested in the present than the future.
28. I am restless at the theater or lectures.
29. I like puzzles.
30. I am future oriented.

Family Tree Questionnaire (FTQ)

Instructions: For each relative listed below, we want you to categorize their behavior into one of six categories. Only include blood relatives; that is, relatives by birth. Not included would be those adopted, half-siblings, and step-relatives.

1=Never Drank: A person who has never consumed alcohol beverages (i.e. lifelong abstainer)
2=Social Drinker: A person who drinks moderately and is not known to have a drinking problem
3=Possible Problem Drinker: A person who you believe or were told might have (had) a drinking problem, but whom you are not certain actually has a drinking problem.
4=Definite Problem Drinker: Only include here persons who either are known to have had received treatment for a drinking problem (including a regular member of Alcoholics Anonymous), or who are known to have experienced several negative consequences of their drinking.
5=No Relative: Only applicable for brothers and sisters
6=Don't Know/Don't Remember

1. Mother
2. Father
3. Your Sister 1
4. Your Sister 2
5. Your Sister 3
6. Your Sister 4
7. Your Brother 1
8. Your Brother 2
9. Your Brother 3
10. Your Brother 4

The Alcohol Use Disorders Identification Test (AUDIT)

Instructions: The following questions are about your use of alcoholic beverages during this past year. Select the number key which corresponds to your answer. Your answer will remain confidential so please be honest. Alcoholic beverages refer to beer, wine, hard liquor, or malt liquor. Keep in mind the size of a standard drink.

1 Beer= 12 oz., 1 Glass of Wine= 5 oz., 1 Glass of Malt Liquor= 9oz., 1 Shot or Mixed Drink= 1.5 oz. of Hard Liquor

1. How often do you have a drink containing alcohol?
    0=Never (Skip to questions 9 & 10)
    1=Monthly or less
    2=2 to 4 times a month
    3=2 to 3 times a week
    4=4 or more times a week
2. How many drinks containing alcohol do you have on a typical day when you are drinking?
    0=1 or 2
    1=3 or 4
    2=5 or 6
    3=7, 8, or 9
    4=10 or more
3. How often do you have six or more drinks on one occasion?
    0=Never
    1=Less than monthly
    2=Monthly
    3=Weekly
    4=Daily or almost daily
4. How often during the last year have you found that you were not able to stop drinking once you has started?
    0=Never
    1=Less than monthly
    2=Monthly
    3=Weekly
    4=Daily or almost daily
5. How often during the last year have you failed to do what was normally expected from you because of drinking?
    0=Never
    1=Less than monthly
    2=Monthly
    3=Weekly
    4=Daily or almost daily
6. How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?
    0=Never
    1=Less than monthly
    2=Monthly

3=Weekly
4=Daily or almost daily

7. How often during the least year have you had a feeling of guilt or remorse after drinking?
0=Never
1=Less than monthly
2=Monthly
3=Weekly
4=Daily or almost daily

8. How often during the last year have you been unable to remember what happened the night before because you had been drinking?
0=Never
1=Less than monthly
2=Monthly
3=Weekly
4=Daily or almost daily

9. Have you or someone else been injured as a result of your drinking?
0=No
2=Yes, but not in the last year
4=Yes, during the last year

10. Has a relative or friend or a doctor or another health worker been concerned about your drinking or suggested you cut down?
0=No
2=Yes, but not in the last year
4=Yes, during the last year

Effortful Control Scale (ECS)

Below are a number of sentences a person might use to describe themselves. Read each sentence; then circle the appropriate number next to each sentence to show how much this sentence describes you.
Indicate how much each sentence describes how you are <u>most of the time.</u>

1=Not at all
2=Not much
3=Somewhat
4=Often
5=Very much

1. I do not complete my homework.
2. I am able to resist laughing or smiling when it isn't appropriate.
3. I really dislike it when someone breaks the rules.
4. I have difficulty completing assignments on time.
5. When I don't get what I want, it's hard to enjoy something else.
6. Whenever I decide anything I always think about whether it's right or wrong.
7. I have a hard time following instructions.
8. I plan and organize my schoolwork very carefully.
9. When an activity or task is difficult, I give up.
10. I find it easy to concentrate on what I am doing.
11. My parent's ideas of how to do things have always proven best.
12. I will move from one task to another without completing any of them.
13. I can easily stop an activity when told to do so.
14. I usually keep at a task or project until it's done.
15. I wait to be called on before speaking.
16. Even little things distract me.
17. I like to stop and think things over before I do them.
18. I leave my own projects or tasks unfinished.
19. I have a hard time concentrating on my work because I'm always thinking about other things.
20. Once I'm involved in a task, nothing can distract me from it.
21. I start many things that I don't finish.
22. I often get lost in my work.
23. I can lower my voice when asked to do so.
24. When I get frustrated with projects or tasks, I quit.

Debriefing: Mood Dysregulation, Heart Rate Variability, and Impulse Control

You were asked to view a set of emotionally relevant pictures, followed by a task that assessed your ability to inhibit motor responses to specific stimuli. We hypothesized that after the emotional picture sets, the ability to inhibit motor responses would be altered and that there would be corresponding changes in cardiovascular functioning.

If you are feeling psychologically distressed, please feel free to contact the Psychological Services Center (PSC) at 614-292-2059.

If you have any questions about this study, please contact Lindsay Cannon at cannon.171@osu.edu or at 614-307-0224, or Dr. Thayer at thayer.39@osu.edu.