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The Effects of Heart Rate Variability, Measures of Impulsivity, and Activity Level in College Students

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THE RELATIONSHIPS OF HEART RATE VARIABILITY, MEASURES OF IMPULSE CONTROL, AND ACTIVITY LEVEL IN COLLEGE STUDENTS

By
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ABSTRACT

LAURA KATIE LAIRD: The Relationships of Heart Rate Variability, Measures of Impulsivity, and Activity Level of College Students.
(Under the direction of Michael T. Allen, Ph.D.)

The objectives of this study were to assess the relationships of breathing-associated heart rate variability and measures of impulsivity using EKG-derived heart rate, the Barratt Impulsivity Scale (BIS-11), and the Conners' Continuous Performance Test (CPT-II). To measure activity level as a proxy for fitness, activity monitors were worn by most participants and all participants completed the International Physical Activity Questionnaire (IPAQ). Fifty-two college students (23 male and 29 female, ages 18-22) participated in the study. Auscultatory blood pressure, EKG-derived heart rate, and mean successive difference of interbeat intervals were collected during 2 ten-minute rest periods and during the CPT-II. Participants were then asked to wear an activity monitor for 24 hours. It was hypothesized that (1) the measures of impulsivity generated by the Barratt would be significantly correlated with CPT-II- derived impulsivity measures; (2) the self-report and activity measures of activity level would both accurately track an individual's activity; (3) Heart rate variability during either rest or task periods would show significant relationships with impulsivity in males only. No significant correlations were found between the BIS-11 and the CPT-II, and no significant correlations were found between measures of the IPAQ and the

activity monitor. A significant positive correlation was found between the number of commissions on the CPT-II and resting HRV, a result opposite from that predicted based upon previous studies. This was found for males only. No significant correlations were found for HRV measures and impulsivity for all participants combined or for females alone. These results suggest a complex relationship between HRV and impulsivity.

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LIST OF ABBREVIATIONS

ANS	Autonomic Nervous System
BIS-11	Barratt Impulsivity Scale (form 11)
BIS Cog	Cognitive Measure of Impulsivity on BIS-11
BIS NP	Non-planning measure of impulsivity on BIS-11
CPT-II	Continuous Performance Test (form 2)
CPT avg	Average Heart Rate Variability during the CPT
HRV	Heart Rate Variability
IPAQ	International Physical Activity Questionnaire
M	Mean
MMPW	Met Minutes per Week
N	Sample size
No. of Comm	Number of Commissions as measured by CPT-II
p	significance (2-tailed)
PNS	Parasympathetic Nervous System
RSA	Respiratory Sinus Arrhythmia
r	Pearson Correlation Coefficient
SD	Standard Deviation
SNS	Sympathetic Nervous System
SPM	Steps per minute

INTRODUCTION

The autonomic nervous system (ANS) regulates smooth muscle, cardiac muscle, and glands. The ANS contains two separate systems: the sympathetic and the parasympathetic divisions. The sympathetic nervous system (SNS) is responsible for mobilizing stored resources during arousal or when excitation is anticipated. The SNS is responsible for increasing blood flow to skeletal muscles and stimulating the secretion of epinephrine which increases heart rate and blood sugar levels. All of these phenomena are a part of the "flight or fight" response. The parasympathetic nervous system (PNS), on the other hand, regulates activities concerned with storing the body's energy resources. The PNS controls activities associated with a relaxed state, such as decreased heart rate and increased activity of the digestive system (Carlson, 2004).

Traditionally, the SNS has been the focus of research involving ANS activation on behavioral states as it is associated with the "flight or fight" response. However, in recent years the PNS has been the subject of closer inquiry. PNS input to the heart, via the vagus nerve, can be indexed by heart rate variability (HRV). HRV is influenced by a number of factors, but the most prominent determinant of resting HRV is the oscillation of heart rate due to breathing; this is called respiratory sinus arrhythmia (RSA; Grossman, 1983). Breathing alters the amount of input from the vagus nerve to the heart, which in turn alters the beat-to-beat heart rate. As discussed later, the degree of PNS input, indexed by breathing-generated HRV, has been associated with health outcomes as well as behavioral flexibility, thus stimulating increased interest in the importance of PNS activation by researchers.

Porges (1995) has suggested that high levels of vagal innervation originating in an area in the medulla called the nucleus ambiguus promote health, growth, and restoration of organs. He has also hypothesized that the removal of the "vagal brake" for short periods of time promotes increased metabolic output and subsequent dominance by the sympathetic nervous system. Diminished HRV results in a loss of flexibility of cardiac control (Eckberg et al., 1971) and this reduction has been associated with increased mortality from sudden cardiac death (Martin et al., 1987). In general, decreased HRV is related to a number of disorders including diabetes, cardiovascular disease, obesity, and lack of physical fitness. One study which followed post-myocardial infarction patients found that decreased HRV is associated with a greater risk of mortality (Stein & Kleiger, 1999). Some interventions associated with increased HRV have been associated with improved survival rates. Decreased HRV has been found to be a highly sensitive indicator of altered autonomic modulation that can identify high-risk patients with diabetes (Stein & Kleiger, 1999).

These associations of HRV and health outcomes are very interesting and important, but further interest in HRV has been generated for psychologists due to recent findings relating HRV to various behavioral states, especially states involving behavioral flexibility. According to a review by Thayer and Siegle (2002), a group of interconnected neural structures called the central autonomic nucleus (CAN) may control HRV and support goal-directed behavior and adaptability. CAN output is mediated by preganglionic sympathetic and parasympathetic neurons, which innervate the heart via the vagus nerve. Input to the sino-atrial node of the heart generates the HRV, and thus the CAN and HRV are directly linked. The CAN receives and integrates environmental information, coordinates behavioral responses to environmental challenges, and is under tonic inhibitory control. The primary inhibitory neurotransmitter is GABA, and disruption of this pathway leads to hypertension and tachycardia. This tachycardia represents a disinhibition of sympathoexcitatory circuits within the CAN. Thayer and Siegle propose that the CNS network and its related systems are associated with the processes of response organization and selection, and they serve to modulate psychophysiological resources in attention and emotion, allowing for "maximal flexibility in adapting to rapidly changing environmental demands." If the network is uncoupled, then the organism is less able to "dynamically assemble the appropriate neural support structures to meet a particular demand and is thus less adaptive (Thayer & Siegle, 2002, p. 25)." Thus, the proposed CAN system provides a link between cardiovascular and behavioral adjustments.

Many studies have found results that support the link between HRV and behavioral flexibility. For example, Pine et al. (1998) found that in urban boys at risk for delinquency, continuous measures of internalizing and externalizing psychopathology were associated with decreased HRV and that these differences could not be explained by any other potential variables such as age, ethnicity, social class, or family history of hypertension. HRV and the ability to sustain attention are positively related in both pre-term and full-term infants (Porges, 1992; Richards & Casey, 1992; Richards, 1994). Adults who experience panic attacks have been found to have lower levels of HRV than the control group of adults (Friedman & Thayer, 1998). The authors speculated that the panic group has both a decreased degree of autonomic flexibility and behavioral self-regulation. Lower levels of HRV have also been found in patients diagnosed with depression (Carney et al., 1999). Calkins and Dedmon (2000) found that 2-year-old boys at risk for aggressive/destructive behavior problems differed from boys in the low-risk group on resting measures of RSA, and both boys and girls in the high-risk group displayed significantly and consistently lower physiological regulation of RSA during challenging situations than did the low-risk group. Having lower levels of HRV indicates a reduction in the cardiovascular system's ability to respond to environmental challenges. The above-mentioned states such as juvenile delinquency, reduced attention, panic attacks and depression reflect a reduction in behavioral adjustments to environment demands. Could these reductions in cardiovascular and behavioral flexibility that both seem to be related to HRV be due to some common controlling mechanisms in the brain such as the CAN?

One widely-cited behavioral manifestation that may be characteristic of decreased behavioral flexibility is reduced impulse control, or impulsivity (Susman, 2006). Is there evidence that impulsivity is related to HRV? In an earlier study designed to address the potential HRV- impulsivity relationship in children and adolescents, HRV was found to be negatively correlated with impulsivity, although this was found in males only (Allen et al., 2000). Despite the fact that only crude measures of impulsivity were obtained using questionnaires from the parents of 8-10 year olds and 15-17 year olds, the correlation was significant and in the expected direction. In a more comprehensive study, Hansen (2003) found that those with high HRV showed a faster mean reaction time and more correct responses with less error on the CPT-II than did the low HRV group. The CPT-II is a computer task widely used in Attention-Deficit/Hyperactivity Disorder research and clinical testing, and it has an impulsivity component in its scoring (CPT-II Software Manual, Conners 2004).

For the present study, we decided to look more specifically at impulsivity using the CPT-II and a questionnaire measure of impulsivity called the Barratt Impulsivity Scale (Patton, 1995). The Barratt Impulsivity Scale is a questionnaire first developed in 1959 which has been revised extensively (see appendix). The current format, the BIS-11, has been found to have potential clinical utility for measuring impulsiveness among selected populations (Patton, 1995). The use of both of these presumed measures of impulsivity would allow us to assess the degree to which the two measures are related to each other as well as whether either or both of them are related to HRV.

One individual difference measure that is related to HRV is aerobic fitness (DeMeersman, 1993). It is known that individuals who are more aerobically fit tend to have lower heart rate due to more efficient pumping action of the heart. This slowing of the heart rate would also be expected to affect HRV as the lower heart rate seen in fit individuals is at least partially mediated by increased PNS activation at rest. Cross-sectional studies have found that highly fit individuals have increased HRV (Goldsmith et. al. 1992), and Stein et al. found that exercise training in healthy older adults increases HRV (1996). It would therefore be desirable to try to control for fitness level of individuals and observe whether impulsivity and HRV are related even when accounting for fitness. However, trying to actually measure fitness level requires costly and time-consuming maximal oxygen uptake assessment which was beyond the scope of this experiment. We decided to try to get a rough estimate of fitness level by measuring activity level of the individual with the logic being that more fit individuals are likely to be more active than their less fit counterparts. We decided to attempt to measure activity level using two different methodologies. First, we tried to get a direct measure of activity level by giving participants the opportunity to wear an activity monitor for a 24-hour period. Second, we decided to use the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003), a survey that asks for the amounts of various activities during the past week (see appendix). We could then observe whether there was a relationship between the two activity measures as well as assess whether controlling for activity level with either of these would influence any observed relationship between HRV and impulsivity.

We therefore have the following hypotheses for this study based upon the existing literature:

- **Hypothesis 1:** Impulsivity measures generated by the CPT-II will be significantly related with the total and subscales of the BIS-11; In other words, the task-generated and self-report measures of impulsivity will be tracking the same behavioral style.
- **Hypothesis 2:** Activity level from the IPAQ will be significantly correlated with the activity level measured by the body monitor. That is, the self-report and activity measures of activity level will both be accurately tracking an individual's activity level.
- **Hypothesis 3:** Heart rate variability during either rest or task periods will show significant relationships with impulsivity. This will be the case when impulsivity is measured from either the CPT-II or the BIS-11. Based upon a previous study by Allen et al. (2000), we hypothesize that the relationships may be present for males but not females.

We have no basis to predict whether controlling for activity level will reduce or eliminate any relationships among impulsivity measures and HRV. We will compute partial correlations among our impulsivity and HRV measures, partialing out activity level from the body monitor or IPAQ, to explore whether the impulsivity/HRV relationships might be mediated by activity level.

METHODS

Participants

Participants were recruited using a sign-up sheet in the Department of Psychology and all were given research credit in their respective Psychology courses. Approximately 5 people were allowed to sign up each week, and because an even distribution of males and females was desired, each week was designated as "males only" or "females only." The sign-up sheet also designated that each person should be at least 18 years of age and be a non-smoker, as it has been found that those who quit smoking have a significant improvements in HRV as compared to HRV of smokers (Stein & Kleiger 1996). Fifty-two students participated in the study, with 23 males and 29 females. Due to equipment problems, four male participants did not have HRV measured, leaving a total of 48 participants (19 males, 29 females). Each participant was given a brief health questionnaire to screen out any students with known cardiovascular disorders or high blood pressure.

Physiological Recording Apparatus

The electrocardiogram (EKG) was transduced using 3 disposable silver-silver chloride electrodes (product number TD-142G; Discount Disposables, St. Albens, VT); 2 were placed just below the collar bone on the right and left sides with the third electrode on the lower right corner of the abdomen. The electrodes were connected to a Coulbourn Instruments Model 575-01 bioamplifier which filtered and amplified the EKG signal and fed it into a Dell personal computer using a Dataq Instruments DI-720 analog-to-digital converter board. Commercially-available software (WindDaq Pro; Dataq Instruments, Akron, Ohio) acquired and displayed the EKG and allowed for calculation of heart rate (HR) and heart rate variability (HRV).

The WINDAQ program identified the peaks of the R-waves of the EKG for each period and placed the interbeat intervals in a spreadsheet. Customized software divided recording periods into one-minute blocks, screened the data for aberrant interbeat intervals, and computed both the mean interbeat interval and mean successive difference (MSD) statistic for the minute periods. MSD is the average of the difference between successive interbeat intervals for a time period. Due to MSD being a differencing technique, low-frequency sources of variability such as linear trends and very slow oscillations are filtered out, leaving oscillations in heart rate due to breathing as the primary influence on heart rate variability (Allen & Matthews, 1997). MSD has been found to track pharmacologically manipulated cardiac vagal control as well as more complicated spectral analysis techniques (Hayano et al., 1991).

A blood pressure cuff was placed on the non-dominant upper arm of each participant. The cuff was connected to a Suntech Tango automated blood pressure monitor (Suntech, Inc., Raleigh, NC) which measured both systolic and diastolic blood pressure as well as heart rate. The monitor used the oscillometric method for determining blood pressure. However, the current study focused only on HRV, so blood pressure data are not reported here.

Experimental Tasks

Conner Continuous Performance Task- Participants completed the Conners' Continuous Performance Test II (CPT-II; Multi Health Systems Inc., North Tonawanda, NY) on a Dell personal computer. Respondents were required to press the left mouse button or spacebar when any letter appeared on the computer screen except "X." Times between stimuli were 1, 2 or 4 seconds, and the stimulus was displayed for 250 milliseconds. The task lasted for 14 minutes. The age range for this program is 6 years and up, and it is based on a database of 2,686 individuals including a sub-sample of individuals with neurological impairment. It provides a confidence index that allows the administrator to judge the certainty of the assessment, and it includes validity checks to screen out certain conditions that may adversely influence the administration. Measures considered to be related to impulsivity are number of commissions (responding to "X" instead of withholding the response), hit reaction time (fast), and perseverations (a response that occurs less than 100 ms after a stimulus—indicating anticipating responding). The task was specifically designed to be somewhat tedious and boring and it has been suggested as being able to diagnose attention deficit disorder. However, the CPT-II was used only to get the 3 impulsivity measures, and all other information was deleted.

Questionnaires

The Barratt Impulsiveness Scale (BIS-11) is a 30-item questionnaire completed by participants to measure the ways participants act and think. The BIS-11 total score has been found to be internally consistent across populations. Each question is scored on a four-point scale and four different sub-scores were used to gauge impulsivity: non-planning, motor, cognitive, and total score.

The International Physical Activity Questionnaire (IPAQ) was used to estimate activity levels during the last 7 days. There are a total of 27 items related to transportation, job-related physical activity, housework or house maintenance, recreational or sport activity, and time sitting. Scoring of the IPAQ allows one to compute the number of met-minutes per week of activity (MMPW) for the individual.

Procedures

Participants reported to the laboratory at their designated time and then read and completed a consent form. Next they filled out a health screening questionnaire, the IPAQ, the Barratt Impulsivity Scale, and two other short questionnaires not reported in this study. These questionnaires took no more than 15 minutes. The participant was weighed, and then asked to sit in a stuffed lounge chair while the blood pressure cuff and electrocardiogram electrodes were applied. Electrodes were placed such that participants would not have to remove their shirts, only moving their shirt or blouse collar to the right or left and lifting up the bottom corner of their shirt or blouse. Additionally, only female experimenters placed electrodes on female participants, but male or female experimenters placed electrodes on male participants. A partition separated the participant area from the equipment and experimenters.

The participants were then asked to sit comfortably in the lounge chair while an initial blood pressure reading was taken and also to ensure that the EKG signal was strong and clear. Instructions were read to the participant asking them to sit and rest quietly for 10 minutes and watch a non-arousing video. Participants were asked to sit still while the blood pressure cuff was inflating and deflating, and to not talk during the 10 minute rest period. The video, "The Hijacked Brain," was meant to be slightly boring but stimulating enough so as to keep the participant awake. During the 10-minute period, blood pressure readings and pulse rate were recorded at 5 minutes, 7 minutes, and 9 minutes into the period. The EKG was continuously recorded throughout the 10 minute period.

Next, the participants were given instructions for the CPT. The experimenter read directions for the CPT to the participant, and then entered the participant's experiment ID number and other necessary information into the computer. The task lasted fourteen minutes, and blood pressure readings were taken at the 1, 3, 5, 7, 9, 11, and 13-minute mark of the task. The EKG was continuously recorded. The participant was again asked to keep their arm as still as possible while completing the task and while the blood pressure cuff was inflating and deflating.

When the CPT was completed, the participant said "finished" and the final rest period immediately began. During the final rest period, the participant was asked to watch the video again for 10 minutes, and the EKG was continuously recorded. Blood pressure readings were taken at the 30 second, 2.5 minute, 7, and 9-minute marks of this second rest period. This portion of the study lasted for approximately one hour, and the participant received 1 ½ hours of research credit for completing this portion of the experiment.

Upon completion of the final rest period, the participant was given the option of wearing an activity monitor (SenseWear by Body Media; Pittsburgh, PA) for one day. If the participant chose to wear the monitor, then the experimenter connected the monitor to the computer and programmed it for the participant's height, weight, gender, and handed-ness. They were asked to go about their normal activities for one day, including sleep periods but excluding showering, and then return it to the laboratory upon which they were given an additional hour of research credit. Individuals wore it for various amounts of time, making it difficult to get a measure of activity that was consistent across individuals. We decided to look at the total amount of time that the participant wore the monitor excluding the amount of time lying down. Fitness was quantified using steps per minute (SPM). This was calculated by subtracting the resting time from the total time worn, and the steps were divided by the total active time that the band was worn. The fitness measure quantified by the IPAQ was met-minutes/per week (MMPW).

Data Analysis

In order to address our hypotheses, we utilized Pearson correlation coefficients to explore relationships among the two impulsivity measures as well as the two activity level measures. Correlation coefficients were also used to examine the relationships of HRV and impulsivity measures. Partial correlations, controlling for activity measures, were then used to examine whether HRV and impulsivity were related even when controlling for activity level. All analyses were run using SPSS for Windows.

RESULTS

Demographic Characteristics

In order to see whether there were differences in demographic variables, we used independent group t-tests to compare males and females on age, height, and weight. Not surprisingly, males and females did differ on height and weight [t (49) =-7. 365, p<.001; t (49) = -6.176; p<.001]. However, it also turned out that males were significantly older than females [t (49) = -2.256; p=.029]. Although we did not expect there to be a significant difference in age, we did not think that this small age difference was problematic for interpreting data.

Table 1: Means and Standard Deviations of age, height, and weight for participants

	Males only		Females only		Overall group	
	Mean	SD	Mean	SD	Mean	SD
Age	19.73	1.751	18.79	1.207	19.20	1.523
Height	71.61	3.551	64.50	3.328	67.71	4.929
Weight	181.74	38.945	129.46	20.141	153.04	39.706

Abbreviation: SD=standard deviation

Measures of Impulsivity and Activity Level

Two measures of impulsivity were collected using the Conner's Continuous Performance Test (CPT-II) and the Barratt Impulsivity Scale (BIS-11). Two measures of activity level were also collected using the Sensewear

Body Media Activity monitors and the IPAQ. The CPT-II also produced an impulsivity measure called perseverations, which are responses that occur less than 100 ms after a stimulus, thus anticipating responding to the next stimulus. However, we did not use this measure because most people committed none of these and the data were not suitable for analysis.

Table 2 reports means, standard deviations, and sample size for HRV, impulsivity, and activity measures. Correlations were performed to determine whether the CPT-II and BIS-11 as well as the Activity Monitor and the IPAQ were comparable measures of impulsivity and fitness, respectively. Table 3 reports correlations between the BIS-11 and CPT-II for all participants, males only, and females only. The total score, non-planning value, motor impulsivity, and cognitive impulsivity measures of the BIS-11 were correlated with the number of commissions and the hit reaction time number of the CPT-II. However, there was no significant correlation in hit reaction time number or any scales of the BIS-11 for the combined male and female group. There was also no significant correlation between hit reaction time number and the BIS-11 when the correlation was performed for males only and for females only.

Table 2: Means, Number of Participants, Standard Deviations for HRV time periods, Activity Measures, and Impulsivity Measures

Variable	N	Mean	SD
No. Commission	52	14.13	6.490
Hit Reaction Time	52	369.6681	41.71124
BIS Total	52	61.81	9.107
BIS NP	52	23.04	4.238
BIS Motor	52	21.50	3.233
BIS Cognitive	52	17.44	4.331
HRV Rest 1	47	41.1959	22.91534
CPT	47	40.1831	22.03399
Rest 2	46	43.2904	25.10438
MMPW	52	5504.7000	4931.38542
SPM	45	11.4010	4.58920

Abbreviations: N=sample size; SD=Standard Deviation; MMPW=met minutes per week (IPAQ measure) SPM=steps per minute (activity monitor measure); No. of Commission = number of commissions (from CPT-II); BIS NP= BIS non-planning

Note: Hit reaction time and HRV is measured in milliseconds. MMPW is met-minutes/week whereas SPM is steps per minute. Number of commissions is the mean frequency of commissions, and BIS values are composite scores.

Table 3: Zero-order Correlations of BIS-11 and CPT-II for all Participants, males only, and females only

		All participants		Males only		Females only	
		No. of Comm	Hit Reaction Time	No. of Comm	Hit Reaction Time	No. of Comm	Hit Reaction Time
BIS Total	r	.040	.051	.006	.227	.045	-.186
	p	.777	.719	.978	.298	.818	.335
BIS NP	r	-.084	.098	-.092	.318	-.099	-.120
	p	.552	.487	.677	.139	.608	.536
BIS Motor	r	.084	.008	.240	.008	-.038	-.011
	p	.555	.957	.271	.971	.844	.955
BIS Cog	r	.154	.000	.035	.185	.233	-.247
	p	.275	.999	.874	.399	.233	.196

Abbreviations: r= Pearson Correlation Coefficient, p= significance (2-tailed), No. of Comm= Number of Commissions from CPT-II

A correlation coefficient was calculated to determine whether or not the two activity measures were related. Overall, a non-significant correlation was found between the 2 measures (see Table 4). For males only, a significant correlation was found between MMPW and SPM in the negative direction

(Pearson correlation (r) =-.463; p=.04). A non-significant correlation was found for the female group. Contrary to our expectations, the body monitor and questionnaire measures of activity level were not significantly correlated for either females or for both genders combined. For males, the measures were negatively correlated, meaning that greater reported activity level was associated with less body monitor activity.

Table 4: Pearson Correlation Coefficients of MMPW and SPM for all participants, males only, and females only

	Combined Group	Males only	Females
Pearson Corr	-.246	-.463	.166
Sig (2-tailed)	.104	.040*	.429
N	45	20	25

Abbreviations: MMPW, met minutes per week; SPM, steps per minute; N=sample size
* indicates p<.05

It would be expected that the BIS-11 and CPT-II measures would be correlated with each other and that the fitness measures would have some correlation. However, since neither had any significant correlations even when divided into male and female groups, it was difficult to decide which measures to use when correlating them with HRV (see Table 3). Since we did not know which impulsivity measure was more accurate, we decided to run the correlations of HRV with both the BIS and the CPT-II variables. Additionally, since neither activity measure is known to be more accurate, we also ran separate partial correlation analyses controlling for each of those activity measures as well.

To compare HRV to the impulsivity measures, there were 3 different HRV periods chosen from the entire 34-minute period. The following periods were analyzed: the last 3 minutes of the first resting period from minutes 8 through 10

(Rest 1), the average HRV of the CPT-II for all 14 minutes (CPT Avg), and the last 3 minutes of the final 10-minute rest period (Rest 2). Only the last 3 minutes of the rest periods were chosen for analysis because participants could still be experiencing anxiety about the experiment during the beginning and immediately following the CPT-II. Although we were primarily interested in HRV during the rest periods, we decided to examine HRV during the CPT-II as well.

Pearson correlations were first calculated without controlling for activity level and are reported in Table 5, Table 6 and Table 7. No significant correlations were found for the combined male and female group for any HRV-impulsivity pairs. Significant correlations were found for males between Rest 1 HRV and number of commissions and Rest 2 HRV and number of commissions, as well as a marginal effect for CPT-II HRV and number of commissions. However, these correlations are positive ones and are therefore in the opposite direction as hypothesized. That is, males with higher numbers of commissions (presumably more impulsive) had higher levels of HRV. No significant correlations were found for females.

Table 5: Zero-order correlations for HRV and Impulsivity measures For all participants

Combined Group	Rest 1HRV		CPT HRV		Rest 2 HRV	
	r	p	r	p	r	p
No. of commissions	.207	.162	.125	.401	.109	.473
Hit Reaction Time	-.224	.130	-.168	.258	-.187	.213
BIS Total	-.227	.125	-.177	.233	-.189	.209
BIS NP	-.183	.219	-.166	.266	-.148	.328
BIS Motor	-.020	.894	-.035	.814	-.013	.931
BIS Cognitive	-.251	.089	-.164	.271	-.237	.113

Abbreviations: BIS NP= BIS-11 non-planning, r= Pearson correlation coefficient, p= significance (2-tailed)

Table 6: Zero-order correlations for HRV and Impulsivity measures For males only

Males only	Rest 1HRV		CPT HRV		Rest 2 HRV	
	r	p	r	p	r	p
No. of commissions	.526*	.021	.485*	.035	.489*	.040
Hit Reaction Time	-.352	.139	-.254	.295	-.303	.222
BIS Total	-.314	.190	-.256	.290	-.256	.305
BIS NP	-.178	.249	-.172	.481	-.208	.408
BIS Motor	-.021	.933	-.067	.784	-.075	.769
BIS Cognitive	-.351	.141	-.312	.194	-.312	.207

Abbreviations: BIS NP= BIS-11 non-planning, r= Pearson correlation coefficient, p= significance (2-tailed)
* indicates p< .05

Table 7: Zero-order correlations for HRV and Impulsivity measures For females only

Females only	Rest 1HRV		CPT HRV		Rest 2 HRV	
	r	p	r	p	r	p
No. of commissions	-.020	.921	-.069	.728	-.112	.569
Hit Reaction Time	-.156	.429	-.159	.418	-.119	.548
BIS Total	-.207	.292	-.168	.391	-.165	.400
BIS NP	-.159	.419	-.181	.357	-.129	.512
BIS Motor	-.040	.839	-.039	.842	.008	.967
BIS Cognitive	-.224	.251	-.122	.538	-.211	.281

Abbreviations: BIS NP= BIS-11 non-planning, r= Pearson correlation coefficient, p= significance (2-tailed)

To control for activity level, partial correlations were performed using both the SPM and the MMPW. For females only, no significant correlation was found between resting HRV and impulsivity measures even when controlling for SPM (see Table 8). When controlling for SPM in males, significant positive correlations were found for the number of commissions and HRV in Rest 1 and Rest 2 respectively (t (12) =.6275; t (12) =.5623, p=.036). The BIS cognitive and HRV were correlated in the expected direction but the p value was not significant. There were no significant correlations for the overall group when controlling for SPM. When controlling for MMPW, there were no significant correlations for females alone or for the overall group when comparing impulsivity measures and

HRV. Significant correlations were found between the number of commissions and Rest 1, CPT Avg, and Rest 2 HRV measures in males only (t(15)=.5493, p= .022; t(15)=.5146, p=.035; t(15)= .4961, p= .043).

Table 8: Partial Correlations of HRV and Impulsivity Measures while Controlling for SPM

HRV Measurement Period		Males only		Females only		Overall group	
		No. of Comm	BIS Cog	No. of Comm	BIS Cog	No. of Comm	BIS Cog
Rest 1	r	.6275*	-.2582	-.1899	-.2098	.1322	-.2071
	p	.016	.373	.613	.337	.429	.212
CPT Avg	r	.5152	-.1988	-.2330	-.0806	.0282	-.1005
	p	.059	.496	.464	.715	.867	.548
Rest 2	r	.5623*	-.1200	-.2767	-.1780	.0136	-.1697
	p	.036	683	.331	.417	.935	.308

Abbreviations: No. of Comm= number of commissions, BIS Cog= BIS-11 Cognitive impulsivity measure, r = Pearson Correlation Coefficient; * indicates p<.05

Table 9: Partial Correlations of HRV and Impulsivity Measures while controlling for MMPW

HRV Measurement Period		Males only		Females only		Overall group	
		No. of Comm	BIS Cog	No. of Comm	BIS Cog	No. of Comm	BIS Cog
Rest 1	r	.5493*	-.3857	-.1018	-.2112	.1965	-.2559
	p	.022	.126	.613	.290	.196	.090
CPT Avg	r	.5146*	-.3917	.1471	-.1063	.0973	-.1715
	p	.035	.120	.464	.598	.525	.260
Rest 2	r	.4961*	-.3445	-.1945	-.1981	-.2112	-.2448
	p	.022	.176	.331	.322	.576	.105

Abbreviations: No. of Comm= number of commissions, BIS Cog= BIS-11 Cognitive impulsivity measure, r= Pearson Correlation Coefficient; * indicates p<.05

DISCUSSION

As was stated in the introduction, we hypothesized that the impulsivity measures generated by the CPT-II (number of commissions and reaction time) would be significantly correlated with the total and subscales of the BIS (Hypothesis 1). No significant correlations were found, however, so it appears that these two tests are measuring different aspects of impulsivity. Therefore, the correlations with HRV were performed with both impulsivity measures as it wasn't apparent which measure, if either, was more accurate.

The two methods of measuring activity also were not correlated. This does not support the hypothesis that the met-minutes per week (MMPW) from the IPAQ would be significantly correlated with the number of steps per minute (SPM) from the body monitor (Hypothesis 2). Therefore, it cannot be determined with any certainty whether the SPM or the MMPW is a more accurate measure of activity level. There are a number of possible reasons for this. This could have occurred because the self-report measures were not accurate. Some participants had difficulty interpreting and answering the questions on the IPAQ survey, and thus their answers may not represent their true activity levels. Additionally, the activity monitors were not worn for consistent lengths of time, and thus contribute to more variation. Also, not all participants were required to wear the bands, as it was given as an option for an extra credit hour. For future studies, the activity monitors should be required to be worn by all participants and for a designated amount of time.

It was hypothesized that heart rate variability during either rest or task periods would show significant relationships with impulsivity on both the BIS-11 and the CPT-II (Hypothesis 3). It was not surprising the there were no correlations found for the combined male and female group. A previous study by Allen et al. (2000) found a HRV-impulsivity relationship for males, but not for females, or for the combined groups. In this study, relationships were found for males only for the number of commissions and HRV; however, there was a positive relationship, rather than the expected negative relationship. Our results show that HRV increases as the number of commissions increased, which would say that males with a greater HRV score higher on that particular measure of impulsivity. In other words, more impulsive males had a greater HRV. Beauchaine's study of comorbid depression and HRV during treatment of conduct-disordered, ADHD boys found that there was no relationship between vagal tone and attention deficit hyperactivity disorder symptoms (2000).

Conners et al. (2004) found that on average, males have a greater number of commissions over the life span than do females. The correlations in our study that were significant were rather large, in the .5 to .6 range. Not only were the correlations not diminished, they actually got somewhat stronger when controlling for activity. It is interesting that the relationship is only found in males and not females, and it is difficult to interpret since previous studies show conflicting results. Thus there exists a complex relationship between HRV, impulsivity, and gender.

One potential limitation of the study is the fact that only 12 males had the proper data to calculate some of the partial correlations controlling for activity level, especially for SPM. Having more participants, particularly males, could improve the confidence of these results.

There was no previous research that predicted that activity level was related to HRV and impulsivity and that controlling for fitness would reduce or eliminate relationships of HRV and impulsivity. Due to the measurement and experimental error, it cannot be concluded with certainty whether activity level is related to HRV and impulsivity. It was disappointing to find so many non-significant correlations. The fact that neither the impulsivity measures nor the activity measures were consistently correlated undermines our confidence that we were getting accurate measurements of impulsivity or activity level. The lack of relationships in the activity measures may be to some error in understanding the questions of the IPAQ by participants, and the variability in the amount of time worn and representativeness of that day to be a typical day in terms of activity may be problematic.

However, we administered the CPT-II and BIS-11 in the prescribed method, and it is unclear why there is not some correlation between them. Impulsivity may be a complex construct with many aspects. Overall, the main problem may be that we simply did not have enough participants. This experiment could be improved by increasing the number of participants and ensuring all equipment is properly functioning, and that all participants are required to do the same things.

LIST OF REFERENCES

Allen, M.T., Matthews, K. A. (1997). Hemodynamic responses to laboratory stressors in children and adolescents: the influence of age, race, and gender. *Psychophysiology 34*, 329-339.

Allen, M.T., Matthews, K.A., Kenyon, K.L. (2000). The relationships of resting baroreflex sensitivity, heart rate variability and measures of impulse control in children and adolescents. *International Journal of Psychophysiology, 37,* 185-194.

Beauchaine, T.P., Gartner, J., Hagen, B. (2000). Comorbid depression and heart rate variability as predictors of aggressive and hyperactive symptom responsiveness during inpatient treatment of conduct-disordered, ADHD boys. *Aggressive Behavior 26,* 425-441.

Calkins, S.D., & Dedmon, S.E. (2000). Physiological and behavioral regulation in two-year-old children with aggressive/destructive behavior problems. *Journal of Abnormal Child Psychology*. 28 (2) : 103-118.

Carlson, N. (2004). *Foundations of Physiological Psychology (5^{th} Ed.).* Boston: Allyn and Bacon.

Carney, R.M., Freedland, K.E., Veith, R.C., Cryer, P.E., Skala, J.A., Lynch, T., & Jaffe, A.S. (1999). Major depression, heart rate, and plasma norepinephrine in patients with coronary heart disease. *Biological Psychiatry. 45,* 458-463.

Conners, K.C. (2004). *Conners' Continuous Performance Test (CPT II) Version 5 for Windows: Technical Guide and Software Manual.* North Tonawanda, NY: Multi-Health Systems, Inc.

DeMeersman, R.E. (1993). Heart rate variability and aerobic fitness. *American Heart Journal, 125,* 726-731.

Eckberg, D.L., Drabinsky, M., & Braunwald, E. (1971). Defective Cardiac parasympathetic control in patients with heart disease. *New England J. Med., 285,* 877-883.

Friedman, B.H., & Thayer, J.F. (1998). Anxiety and autonomic flexibility: A cardiovascular approach. *Biological Psychology, 47,* 243-263.

Goldsmith R.L., Bigger J.T. Jr, Steinman RC, Fleiss JL. 1992. Comparison of 24-hour parasympathetic activity in endurance-trained and untrained younger men. *J. Am. Coll. Cardiol.* 20:552-8.

Grossman, P. (1983) Repiration, stress, and cardiovascular function. *Psychophysiology, 20,* 284-300.

Hansen, A.L. (2003). Vagal influence on working memory and attention. *International Journal of Psychophysiology. 48(3),* 263-274.

Hayano J., Sakakibara, Y., Yamada, A., et al. (1991). Accuracy of assessment of cardiac vagal tone by heart rate variability in normal subjects. *Am J Cardiol., 67,* 199-204.

Martin, G.J., Magid, N.H., Myers, G., et al. (1987). Heart rate variability and sudden death secondary to coronary artery disease during ambulatory electrocardiographic monitoring. *Am. J. Cardiol., 60,* 555-563.

Patton, J.H., Stanford, M.S., & Barratt, E.S. (1995). Factor Structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology. 51(6):* 768-774.

Pine, D.S., Wasserman, G.A., Miller, L. et al. (1998). Heart rate variability and psychopathology in urban boys at risk for delinquency. *Psychophysiology, 35,* 521-529.

Porges, S.W. (1992) Autonomic regulation and attention. In Campbell, B.A. Hayne, H., & Richardson, R. (eds.). *Attention and information processing in infants and adults.* Hillsdale, NJ: Erlbaum.

Porges, S.W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A Polyvagal Theory. *Psychophsiology, 32,* 301-318.

Richards, J.E. (1994). Baseline respiratory sinus arrhythmia and h eart rate responses during sustained visual attention in preterm infants from 3 to 6 months of age. *Psychophysiology, 31,* 235-243.

Richards, J.E., & Casey, B.J. (1992). Development of sustained visual attention in the human infant. In Campbell, B.A., Hayne, H., & Richardson, R. (eds.). *Attention and information processing in infants and adults.* Hillsdale, NJ: Erlbaum.

Stein, P.K. & Kleiger R.E. (1999). Insights from the study of heart rate variability. *Annual Reviews in Medicine. 50*: 249-61.

Stein P.K., Rottman J.N., Kleiger R.E.. 1996. Effect of 21 mg transdermal nicotine patches and smoking cessation on heart rate variability. *Am. J. Cardiol.* 77, 701-5.

Stein P.K., Rottman JN, Kleiger RE, Ehsani AA. (1996). Exercise training increases heart rate variability in normal older adults. *J. Am. Coll. Cardiol.* 27 (2), 146A.

Susman, E.J. (2006). Psychobiology of persistent antisocial behavior: stress, early vulnerabilities and the attenuation hypothesis. *Neuroscience & Biobehavioral Reviews, 30,* 376-389.

Thayer, J.F. & Siegle, G.J. (2002). Neurovisceral integration in cardiac and emotional regulation. *IEEE Engineering in Medicine and Biology, 21,* 24-29.

APPENDIX

CARDIOVASCULAR AND BEHAVIORAL RESPONSE STYLE STUDY
DATA SHEET

Subject Code: __________ Date: __________

Age: ____________ Height: ______ in. Weight: _____ lbs.

Gender: F M Ethnicity (optional): ____________________

	BP (Sys/Dia), HR (bpm)	WinDaq File Name
Rest 1 (10 Min)	5:00 ________________	ALL MIN
	7:00 ________________	________________
	9:00 ________________	
Conner CPT (14 MIN)	1:00 ________________	ALL MIN
	3:00 ________________	________________
	5:00 ________________	
	7:00 ________________	
	9:00 ________________	
	11:00 ________________	
	13:00 ________________	
Rest 2 (10 MIN)	0:30 ________________	ALL MIN
	2:30 ________________	________________
	7:00 ________________	
	9:00 ________________	

Conner CPT Scores:

	Value	T-score	Percentile	Guideline
Commissions	_____	______	________	_________
Hit RT	_____	______	________	_________
Perseverations	_____	______	________	_________

(These values are found on page 6 of Conner profile report.)

Comments:

Personal Evaluation: BIS-11

Name: ______________________ *Date:* __________

Directions: 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 carefully and **DARKEN THE APPROPRIATE CIRCLE** to the right of the statement. Answer quickly and honestly.

		Rarely/Never	Occasionally	Often	Almost Always
1.	I plan tasks carefully	O	O	O	O
2.	I do things without thinking	O	O	O	O
3.	I make up my mind quickly	O	O	O	O
4.	I am happy-go-lucky	O	O	O	O
5.	I don't "pay attention"	O	O	O	O
6.	I have "racing" thoughts	O	O	O	O
7.	I plan trips well ahead of time	O	O	O	O
8.	I am self-controlled	O	O	O	O
9.	I concentrate easily	O	O	O	O
10.	I save regularly	O	O	O	O
11.	I "squirm" at plays or lectures	O	O	O	O
12.	I am a careful thinker	O	O	O	O
13.	I plan for job security	O	O	O	O
14.	I say things without thinking	O	O	O	O
15.	I like to think about complex problems	O	O	O	O
16.	I change jobs	O	O	O	O
17.	I act "on impulse"	O	O	O	O
18.	I get easily bored when solving thought problems	O	O	O	O
19.	I act on the spur of the moment	O	O	O	O
20.	I am a steady thinker	O	O	O	O
21.	I change where I live	O	O	O	O
22.	I buy things on impulse	O	O	O	O
23.	I can only think about one problem at a time	O	O	O	O
24.	I change hobbies	O	O	O	O
25.	I spend or charge more than I earn	O	O	O	O
26.	I have outside thoughts when thinking	O	O	O	O
27.	I am more interested in the present than the future	O	O	O	O
28.	I am restless at lectures or talks	O	O	O	O
29.	I like puzzles	O	O	O	O
30.	I plan for the future	O	O	O	O

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ Yes

☐ No → ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ **days per week**

☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity → ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**
_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**
_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**
_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**
_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**
_____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day**
_____ **minutes per day**

This is the end of the questionnaire, thank you for participating.