Psychiatr Q (2017) 88:103–114
DOI 10.1007/s11126-016-9437-z

Physiological Arousal and Juvenile Psychopathy: Is Low Resting Heart Rate Associated with Affective Dimensions?

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Published online: 9 May 2016

Abstract A wealth of past research has examined the relationship between low physiological arousal and violence or antisocial behavior. Relatively little research; however, has examined the relationship between low physiological arousal and psychopathic traits, with even less having been conducted with juveniles. The current study attempts to fill this gap by evaluating juveniles' physiological arousal using resting heart rate and their levels of psychopathic traits. Results suggest that there is indeed an inverse relationship between resting heart rate and the affective traits of psychopathy (Uncaring, Callousness, and Unemotionality) as well as Thrill or Sensation Seeking in males. No significant relationship was found in females. Implications of the findings as well as study limitations and future directions are discussed.

Keywords Low physiological arousal · Psychopathy · Juveniles · Affective traits

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Introduction

A key component in human emotional experience is autonomic arousal [1]. When an individual experiences a significant stressor, the sympathetic nervous system activates and releases stress hormones which, among other things, combine with a withdrawal of vagal influences to cause an increased heart rate [1, 2]. Thus, some theories of temperament explain traits such as extraversion and introversion in terms of autonomic reactivity (i.e., those who experience greater autonomic reactivity to stressors require less stimulation and are less sensation seeking) [3]. Such findings led some to hypothesize that low autonomic arousal might be a factor in traits such as aggression.

A wealth of past research has been conducted on autonomic arousal, especially heart rate, and its association to violence. In a review of previous studies, Raine [4] reported that low physiological arousal, as assessed by low resting heart rate, is the most reliable biological predictor of aggression and violence in juveniles. Similarly, Lorber [5] conducted a meta-analysis of 95 studies and found that low resting heart rate correlates strongly with aggression and conduct problems. In the same year, Ortiz and Raine [6] revealed results from a meta-analysis of 40 studies and reported that low resting heart rate is the most robust and replicable predictor of antisocial behavior in children and adolescents. Indeed, low resting heart rate has recently been characterized as an "unequivocal" risk factor for both the perpetration of violence and exposure to violence [7].

Another construct of interest, due to its similarity to antisocial behavior spectrum disorders, is psychopathy. Psychopathy is commonly viewed as a personality construct or cluster of relatively stable traits, including impulsivity, callousness, disinhibition, manipulation, dishonesty, and grandiosity [8–12]. Copious research findings have shown that psychopathy is significantly associated with an array of antisocial and other problem behaviors, including conduct problems, delinquency, externalizing symptoms, crime, and violence. Due to the numerous studies that have found a link between low physiological arousal and antisocial behavior [4–6, 13], it is somewhat surprising that little research has examined the relations between low physiological arousal and psychopathy facets. At the very least, it seems plausible that low physiological arousal should be related to the affective dimensions of juvenile psychopathy such as Callous-Unemotionality and Uncaring.

The present study aims to expand on the existing literature on the etiology of juvenile psychopathy by specifically examining a link between low physiological arousal, measured using resting heart rate, and psychopathic features. We hypothesize that low physiological arousal will be associated with affective facets of psychopathy such as Uncaring and Callous Unemotionality. We examine this hypothesis by using a non-offender sample, thereby reducing the confounding influence of prior antisocial behavior.

Method

Participants

Data for the present study are derived from a randomized reading intervention designed to remediate the reading difficulties of middle grade struggling readers. This study was conducted in three middle schools from three different school districts in the midwestern United States. The mean enrollment of the three middle schools was 387 students (ranging from 310 to 512 students). Across the schools, the mean percentage of students eligible for

free or reduced lunch was 52 % (range: 35–67 %). Student ethnicity varied slightly across the schools; however, each school included a high percentage (at least 80 %) of White students.

Students in grades 6 through 8 were selected to participate based on their prior-year performance on the standardized state test for reading. Specifically, students who scored at or below "basic" on the prior-year Missouri Assessment Program [14] were recruited for participation in the study. A total of 180 students across the three schools consented to participate and were randomly assigned by using a 2:1 ratio to treatment ($n = 120$) and a business-as-usual comparison condition ($n = 60$). We used a 2:1 ratio of treatment to comparison to meet the schools' request for providing treatment to as many students as possible.

After randomization, parents for 46 of the 180 students requested their child not participate in the study ($n = 35$ treatment and $n = 11$ control). We did not find differential attrition between students who remained in the study and those who left the study in terms of demographics ($ps > 0.05$) or performance on most of the academic assessments administered at pretest ($ps > 0.05$). Seven of the remaining students ($n = 134$) did not have pulse data collected, resulting in the final sample of 129 students. Of these, 45 % were female and 75 % of the students were eligible for free or reduced lunch. The racial/ethnic composition of the final sample was 79 % Caucasian, 11 % African American, 3 % Hispanic, and 7 % other. Students were on average 12 years old across grades 6–8. See Table 1 for additional student demographic data.

Table 1 Demographics

Variable	Frequency	Percent
Grade		
6	49	37.98
7	53	41.09
8	27	20.93
Gender		
Male	69	53.49
Female	58	44.96
Missing	2	1.55
Free/reduced lunch		
No	30	23.26
Yes	97	75.19
Missing	2	1.55
Race		
Caucasian	102	79.07
African American	14	10.85
Hispanic	4	3.10
Other	7	5.43
Missing	2	1.55
	M	*SD*
Age	12.15	0.87

Measures

Physiological Arousal

Physiological arousal was measured by using wrist pulse readings and pulse oximeter readings of heart rate. Resting heart rate is a commonly used measure of physiological arousal [15–19]. Iyriboz et al. [20] found that pulse oximeter measures of heart rate highly correlate with electrocardiogram measures of heart rate when the individual is at rest. Measuring heart rate through checking the pulse in the hand is the traditional favorite of exercise and medical professionals [21, 22]. Students were individually assessed in a quiet room assigned by the principal. Students were asked to sit at a small table and rest for 10 min prior to obtaining three wrist pulse readings and pulse oximeter readings of heart rate. The averages of wrist pulse readings and pulse oximeter readings of heart rate were used in analyses.

Psychopathy

The Youth Psychopathic Traits Inventory (YPI) [23] is a 50-item self-report questionnaire that measures core personality dimensions of psychopathy with a three-factor structure: grandiose-manipulative, callous-unemotional, and impulsive-irresponsible. The grandiose-manipulative dimension is composed of four subscales: dishonest charm, lying, grandiosity, and manipulation. The callous-unemotional dimension is composed of three subscales: callousness, unemotionality, and remorselessness. The impulsive-irresponsible dimension is composed of three subscales: impulsiveness, irresponsibility, and thrill seeking. The questionnaire uses a 4-point Likert scale ranging from 1 = does not apply at all to 4 = applies very well [24]. Total scores range from a minimum of 50 points to a maximum of 200 points. The greater a student's score, the more a student exhibits characteristics of callousness, and appears unemotional, impulsive, manipulative, and irresponsible.

The YPI was administered in small groups. Each item was read aloud to students. On the first three items, the Likert scale was also read aloud to students. For the purposes of this study, we used a modified 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). Prior research has found the YPI to be a useful and valid measure of psychopathy among juveniles [24, 25].

Callous-Unemotional Traits

The Inventory of Callous-Unemotional Traits (ICU) [26] is a 24-item youth self-report questionnaire that measures students' callous and unemotional traits. The ICU was originally evaluated with a sample of German students in grades 7–10 who ranged in age from 13 to 18 ($M = 15.59$, $SD = 1.56$; [26]). The content of the ICU was based on the Antisocial Process Screening Device, which used a six-item scale of callous-unemotional traits. The questionnaire uses a 4-point Likert scale (0 = not at all true, 1 = somewhat true, 2 = very true, 3 = definitely true). Total scores range from a minimum of 0 points to a maximum of 72 points. The greater a student's score, the more a student exhibits characteristics of being callous and unemotional.

The ICU was administered in small groups. Each item was read aloud to students. On the first three items, the Likert scale was also read aloud to students. Essau et al. [26] first

evaluated this scale and identified a three-factor model (Uncaring, Callousness, and Unemotional) with a single higher-order factor (Callous-Unemotional) as the best-fitting model. Internal consistency for the whole scale was acceptable, with a coefficient alpha of 0.77. Internal consistency was also acceptable for the callousness ($\alpha = 0.70$) and uncaring ($\alpha = 0.73$) factors. Internal consistency was marginal for the unemotional factor ($\alpha = 0.64$), which the authors suggest may be a result of the short scale length (five items).

Data Analysis

Summaries of descriptive statistics are presented in Tables 2 and 3. A correlation matrix was computed separately for males and females to examine the bivariate association between low physiological arousal and the various psychopathy subscales. In addition, a series of linear regression analyses was performed with low physiological arousal as a predictor explaining the severity of psychopathy traits that were significant at the bivariate level. These analyses controlled for age and socioeconomic status (SES) and were conducted separately for males and then with all participants by using gender as an interaction term. All analyses were computed by using Stata 13.

Results

Bivariate correlations revealed that low physiological arousal, as measured by the average of pulse wrist and oximeter readings, is inversely associated with several subscales from the YPI and ICU for males but not for females (see Tables 4 and 5). Low physiological arousal was significantly associated with the Uncaring subscale from the ICU ($r = -0.29$, $p = 0.017$), and the Dishonest charm ($r = -0.20$, $p = 0.095$), Callousness ($r = -0.24$, $p = 0.05$), Unemotionality ($r = -0.24$, $p = 0.047$), and Thrill Seeking ($r = -0.27$, $p = 0.024$) subscales from the YPI.

Next, two sets of regression models were fit separately for each outcome to see whether the relationships of low physiological arousal and psychopathy traits hold even after controlling for SES and age (see Table 6). Model 1 included only pulse measure predicting psychopathy traits. Model 2 included hierarchical regression models in which pulse measure was entered after SES and age. Results from Model 2 indicated that low physiological arousal was significantly predictive of Uncaring from the ICU ($B = -0.014$, $p = 0.02$), and Unemotionality (B = −0.011, $p = 0.051$), Callousness (B = −0.009, $p = 0.069$), and Trill Seeking (B = −0.009, $p = 0.038$) from the YPI. Dishonest charm was no longer significant after controlling for SES and age.

Table 2 Description and distribution of pulse by gender

	Mean	*SD*	Minimum	Maximum	Skewness	Kurtosis
Total	83.37	12.23	52	108	−0.23	2.50
Male	83.92	11.82	57.5	108	−0.16	2.36
Female	82.84	12.85	52	105.5	−0.30	2.57

Table 3 Descriptive and Internal consistency reliability for psychopathic scales by gender

Scales	# Item	Total ($N = 129$)			Male ($N = 69$)			Female ($N = 58$)		
		Alpha	*M*	*SD*	Alpha	*M*	*SD*	Alpha	*M*	*SD*
ICU										
Callousness	11	0.67	1.68	0.38	0.68	1.75	0.37	0.67	1.59	0.36
Uncaring	8	0.83	1.99	0.60	0.83	2.14	0.60	0.80	1.80	0.55
Unemotionality	5	0.56	2.59	0.55	0.50	2.72	0.52	0.57	2.43	0.56
YPI										
Dishonest charm	5	0.66	2.14	0.57	0.59	2.21	0.52	0.73	2.04	0.36
Grandiosity	5	0.65	2.07	0.57	0.55	2.22	0.52	0.71	1.90	0.55
Lying	5	0.74	2.11	0.64	0.74	2.25	0.65	0.71	1.94	0.56
Manipulation	5	0.84	2.04	0.67	0.84	2.14	0.65	0.84	1.92	0.61
Callousness	5	0.41	2.26	0.50	0.41	2.42	0.50	0.40	2.05	0.59
Unemotionality	5	0.65	2.46	0.59	0.60	2.57	0.53	0.60	2.28	0.60
Remorselessness	5	0.60	2.25	0.55	0.70	2.34	0.57	0.42	2.13	0.68
Impulsiveness	5	0.65	2.52	0.56	0.65	2.56	0.52	0.63	2.46	0.41
Irresponsibility	5	0.69	1.90	0.60	0.66	2.03	0.61	0.68	1.73	0.58
Thrill seeking	5	0.33	2.38	0.44	0.33	2.52	0.41	0.29	2.21	0.50

ICU Inventory of Callous-Unemotional Traits, *YPI* Youth Psychopathic Trait Inventory

Discussion

The purpose of the current study was to evaluate the relationship, if any, between low physiological arousal and psychopathic traits among middle school students with no history of criminal offence. The results suggest an inverse relationship between physiological arousal and several YPI and ICU traits in males. Specifically, the results indicate a link between low physiological arousal and the affective features of psychopathy (Uncaring, Callousness, and Unemotionality), as was predicted. This link held up even when controlling for age and SES, as did a similar relationship between low physiological arousal and thrill seeking.

These findings contribute to and expand upon the existing literature on the etiology of psychopathy in juveniles. Although there is no proof of causality, a possible explanation for this relationship comes from modern theories of emotion that credit physiological arousal with a significant role in the experience of emotion [1]. In other words, juveniles with a significantly lower resting heart rate may experience this low level of arousal as a lack of emotion or caring. They also would require greater stimulation to increase their heart rates to a high level of arousal, which could explain thrill-seeking behavior. The link between low physiological arousal and thrill seeking, also known as sensation seeking, has been demonstrated in previous research [27] and might be explained by Eysenck's [28] stimulation-seeking theory, which posits that individuals experience a lack of arousal as a negative or unpleasant feeling and pursue activities to raise their arousal to a more comfortable level. Eysenck's three-factor model of personality (extraversion, neuroticism, and psychoticism) places sensation seekers on the high end of extraversion and hypothesizes

Table 4 Zero-Order correlations among variables for males ($N = 69$)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Pulse	–													
2	Callousness (ICU)	−0.09	–												
3	Uncaring (ICU)	−0.29	0.50	–											
4	Unemotionality (ICU)	−0.05	−0.14	0.05	–										
5	Dishonest charm	−0.20	0.14	0.27	−0.14	–									
6	Grandiosity	−0.12	0.36	0.35	−0.14	0.63	–								
7	Lying	−0.14	0.41	0.39	−0.12	0.53	0.61	–							
8	Manipulation	−0.05	0.19	0.28	−0.11	0.78	0.60	0.64	–						
9	Callousness	−0.24	0.29	0.47	0.10	0.19	0.42	0.25	0.23	–					
10	Unemotionality	−0.24	0.24	0.22	0.08	0.43	0.52	0.46	0.43	0.34	–				
11	Remorselessness	−0.04	0.19	0.10	−0.11	0.40	0.59	0.55	0.46	0.15	0.61	–			
12	Impulsivity	−0.09	0.06	0.17	0.15	0.45	0.48	0.48	0.45	0.17	0.37	0.42	–		
13	Irresponsibility	−0.07	0.26	0.35	0.15	0.40	0.42	0.59	0.53	0.37	0.56	0.42	0.48	–	
14	Thrill seeking	−0.27	0.30	0.28	0.08	0.29	0.45	0.50	0.35	0.19	0.40	0.42	0.55	0.32	–

Correlation coefficients at or above 0.24 or at or below −0.24 are statistically significant at 0.05 alpha level. Correlation coefficients at or above 0.20 or at or below −0.20 are statistically significant at 0.1 alpha level

ICU Inventory of Callous-Unemotional Traits

Table 5 Zero-order correlations among variables for females ($N = 58$)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Pulse	–													
2	Callousness (ICU)	−0.01	–												
3	Uncaring (ICU)	0.05	0.52	–											
4	Unemotionality (ICU)	0.14	0.38	0.43	–										
5	Dishonest charm	−0.10	0.41	0.34	−0.02	–									
6	Grandiosity	−0.03	0.39	0.39	0.01	0.53	–								
7	Lying	−0.03	0.35	0.38	0.17	0.47	0.47	–							
8	Manipulation	−0.13	0.56	0.46	0.06	0.71	0.68	0.65	–						
9	Callousness	−0.01	0.51	0.43	0.18	0.57	0.35	0.27	0.50	–					
10	Unemotionality	0.00	0.33	0.22	0.29	0.31	0.35	0.20	0.43	0.33	–				
11	Remorselessness	−0.21	0.35	0.33	0.21	0.50	0.35	0.50	0.58	0.17	0.38	–			
12	Impulsivity	−0.01	0.36	0.40	0.20	0.43	0.44	0.46	0.57	0.05	0.36	0.65	–		
13	Irresponsibility	−0.15	0.40	0.47	0.14	0.48	0.45	0.48	0.60	0.34	0.38	0.59	0.47	–	
14	Thrill seeking	−0.09	0.36	0.26	0.09	0.26	0.32	0.41	0.54	0.29	0.35	0.35	0.27	0.42	–

Correlation coefficients at or above 0.26 or at or below −0.26 are statistically significant at 0.05 alpha level. Correlation coefficients at or above 0.22 or at or below −0.22 are statistically significant at 0.1 alpha level

ICU Inventory of Callous-Unemotional Traits

Table 6 Regression results

Outcome	Model 1 (N = 69)				Model 2 (N = 66)			
	Predictor	Coefficient	*SE*	*P*	Predictor	Coefficient	*SE*	*p*
ICU: Uncaring	Pulse	−0.015	0.006	0.016	SES	−0.237	0.154	0.129
	Constant	3.379	0.507	0.000	Age	0.118	0.082	0.156
					Pulse	−0.014	0.006	0.020
					Constant	2.012	1.128	0.079
YPI: Unemotionality	Pulse	−0.011	0.005	0.047	SES	−0.179	0.146	0.224
	Constant	3.478	0.451	0.000	Age	−0.038	0.078	0.629
					Pulse	−0.011	0.005	0.051
					Constant	4.074	1.070	0.000
YPI: Callousness	Pulse	−0.010	0.005	0.050	SES	−0.304	0.133	0.026
	Constant	3.266	0.426	0.000	Age	−0.026	0.071	0.713
					Pulse	−0.009	0.005	0.069
					Constant	3.741	0.978	0.000
YPI: Dishonest charm	Pulse	−0.009	0.005	0.095	SES	−0.102	0.129	0.434
	Constant	2.955	0.446	0.000	Age	0.164	0.069	0.021
					Pulse	−0.008	0.005	0.108
					Constant	0.969	0.948	0.311
YPI: Thrill seeking	Pulse	−0.009	0.004	0.024	SES	−0.174	0.108	0.111
	Constant	3.308	0.343	0.00	Age	0.026	0.058	0.650
					Pulse	−0.009	0.004	0.038
					Constant	3.047	0.790	0.000

ICU Inventory of Callous-Unemotional Traits, *YPI* Youth Psychopathic Trait Inventory

that an individual's level of extraversion is dependent on his or her baseline arousal level (i.e., low arousal predicts extraversion and sensation seeking) [28–30].

The results did not indicate similar links in females, but the lack of a significant relationship between low physiological arousal and psychopathic traits in females is not surprising, considering past research. Previous studies have found that female psychopaths tend to score higher on empathic concern, perspective taking, and personal distress [31]. Similarly, Vitale et al. [32] found that female psychopaths score higher on measures of anxiety and negative affect than other studies have found in men. Because anxiety is linked to increased physiological arousal [33], it seems logical that there would be less association between low physiological arousal and psychopathic traits in females than in males.

It is surprising, however, that there is no evidence for an association between low physiological arousal and impulsivity. One might assume that if there is a link between low physiological arousal and sensation or thrill seeking that such a trait would also correlate with impulsiveness (i.e., the desire to seek out sensation might result in acting without hesitation or consideration of consequences). The lack of an association may suggest that instead of being spurred by a motivation to seek stimulation, the impulsivity seen in psychopaths is more a function of the deficits in executive function and general intelligence typical of that population [34, 35]. Such a conclusion is reasonable when one considers the definition of impulsivity as "actions that are poorly conceived, prematurely expressed,

unduly risky, or inappropriate to the situation and that often result in undesirable outcomes" [36].

The current study does have some limitations. First, the small total sample size resulted in small comparison groups (e.g., gender) and moderate power to detect small differences. Second, resting heart rate was assessed at only one point in time, albeit using three hand readings and three oximeter readings. As such, this assessment procedure may not represent each individual's average resting heart rate with complete accuracy. Additional assessments of resting heart rate might control for confounding variables that could result in elevated heart rates (e.g., a fight earlier in the day, an issue at home).

Because a search of the literature revealed no other studies examining low physiological arousal and psychopathic traits, replication studies are needed to see whether the results hold up. Additionally, future studies could address not only resting heart rate, but also heart rate reactivity in relationship to these traits. Despite the preliminary nature of the present study, these set of findings provide an initial starting point for future studies on physiological arousal and psychopathic features.

Acknowledgments The authors are grateful for support from Department of Education R305F100013 (Dr. Sharon Vaughn) and NIH Grants: K08 HD068545-01A1 (Dr. Barth). The authors are also grateful for support from the Texas Education Agency, Meadows Center for Preventing Educational Risk, the Institute on Educational Sciences Grants (R305F100013, R305A150058, R324A100022 & R324B080008), and the Eunice Kennedy Shriver National Institute of Child Health and Human Development (P50 HD052117).

Complaints with Ethical Standards

Conflict of Interest The authors have no conflicts of interest to report.

Informed Consent The institutional review boards of the participating universities approved the conduct of this research, as did the school districts. All study participants provided their informed consent.

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