THE EFFECT OF ADVERSE CHILDHOOD EXPERIENCES ON AUTONOMIC ACTIVITY IN ADULTHOOD

By

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ABSTRACT

Rebekah Breithaupt

The Effects of Adverse Childhood Experiences on Autonomic Activity in Adulthood (Under the direction of DR. TADD PATTON)

Adverse childhood experiences (ACEs) are a significant and highly prevalent issue. ACEs include physical, psychological, and sexual abuse, dysfunction in the home, parental loss through divorce and or death, and other potentially traumatic events (Felitti et al., 1998). More research is needed to gain a better understanding of how ACEs are linked to long-term negative mental health outcomes and physiology. A non-invasive way to understand the relationship between adversity and mental and physical health is to examine physiological activity patterns of the autonomic nervous system (sympathetic and parasympathetic). Such physiological measures include electrodermal activity (EDA), heart rate (HR), and heart rate variability (HRV). The purpose of this study was to investigate if certain autonomic activity patterns are associated with ACEs and if these activity patterns can be observed in early adulthood. To do this, EDA, HR, and HRV were collected from participants during a baseline period of rest and while they completed a stressful task (Stroop Test). Additionally, participants were measured in this study using the Adversity and Abuse Items from the Harvard Second Generation Study Questionnaire (Morrill et al., 2019). Certain demographic information is also being collected. The hypotheses of this study were as follows: 1) Individuals who score high on the ACEs scale will display higher levels of HR and EDA at baseline than those with low scores, 2) individuals who score high on the ACEs scale will have higher HR and EDA during the stress task than those with low ACEs scores, and 3) Participants in the high

ACEs group will have lower overall HRV than those in the low ACEs groups. The results of this study did not show any significant differences between ACEs groups and their physiological measures during baseline or during the Stroop task.

KEYWORDS: autonomic activity, adverse childhood experiences, trauma, physiology

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I. INTRODUCTION

Statement of the Problem

A significant amount of attention has been given to the effects of early life trauma and adversity on mental and physical health outcomes in adulthood. The term adverse childhood experiences (ACEs) as originally defined by Felitti et al. (1998), includes physical, psychological, and sexual abuse, dysfunction in the home, parental loss through divorce and or death, and other potentially traumatic events. Since the creation of the concept, this definition has been updated to include exposure to violence, living in unsafe areas, bullying and social isolation, major life transitions like gaining step-parents, and other experiences that can cause significant stress in children (Morrill et. al, 2019). ACEs are a serious and highly prevalent issue. Between 2015 and 2017, the Behavioral Risk Factor Surveillance System (BRFSS) collected data from 27 states. Of the 144,017 respondents, 60.9% reported experiencing at least one type of ACE, and 15.6% reported experiencing four or more types (Hege et al., 2020). ACEs are associated with psychological concerns in adulthood. A study on mental health in college students found ACEs to be a significant predictor for the development of anxiety or depressive disorders (Karatekin, 2017). ACEs were also found to be associated with increased risk for suicidal ideation and suicide attempts (Afifi et al., 2008). There is also evidence for a cumulative effect of ACEs on mental health. Afifi et al. (2008) found that as the number of ACEs increased, the odds of a person having a psychiatric disorder also increased. Furthermore, Chapman et al. (2004) found that the more ACEs participants reported, the higher the likelihood they suffered from lifetime or recent depressive disorders.

Review of the Literature

1. ACEs and Health Concerns

In addition to the psychological consequences of ACEs, studies have established a link between adverse experiences in childhood and chronic physical health issues in adulthood such as cardiovascular disease, diabetes, obesity, and depression (Herzog & Schmahl, 2018). The CDC (2019) reports that some of the leading causes of death in the United States include heart disease, cancer, and chronic respiratory infections. ACEs have been demonstrated to have a significant association with these very health outcomes (Felitti et al., 1998; Merrick et al. 2019). Adult health outcomes also follow a similar cumulative trend with ACEs. The risks compound, with people who report multiple types of ACEs showing higher rates of multiple health risks as adults (Martín-Higarza et al., 2020). People who have experienced ACEs are also significantly more likely to report poorer perceived health and quality of life. Similar to the trend of incidences of chronic health concerns, the more ACEs a person reported, the lower their perception of their health (Martín-Higarza et al., 2020). Poor perception of health has been linked as a predictor of mortality (Felitti et al., 1998).

Additionally, there is some debate regarding the exact mechanism through which ACEs affect future health. Some evidence shows that people who have experienced ACEs are more likely to engage in behaviors that can be significant contributing factors to poor physical health including smoking, heavy drinking, taking illegal drugs, and engaging in sexually risky behavior that increases their risk of sexually transmitted infections (Felitti et al., 1998; Merrick et al, 2019). Another leading theory is that ACEs occur more frequently in vulnerable populations who experience more stress in adulthood based on race, gender, or socioeconomic status, and that, compounded with a lack of resources, creates a poor perceived quality of life and physical health (Hege et all, 2020; Martín-Higarza et al., 2020). Clearly, the long-term effects of ACEs are significant, and the mere prevalence of the negative health outcomes indicates a need to gain a better understanding of how adversity can impact the body.

2. ACEs and the Brain

Moreover, early exposure to trauma and extreme stress can have significant impacts on brain development and neural plasticity. An overabundance of stress hormones like cortisol can cause a decline in cognitive functioning and physical changes to brain structures (McEwan, 2013). Specifically, chronic stress is linked to reduced brain matter, changes in the prefrontal cortex which controls decision making and impulsive behaviors, and changes in the amygdala and hippocampus, the brain structures concerning memories as well as fear and other emotions, (Bryan, 2018). ACEs are also linked with an overactive hypothalamic-pituitary-adrenal (HPA) axis leading to the constant perception of threat even when no threat is present. This overactivity is due to the overproduction of cortisol which overwhelms the HPA axis. Some evidence suggests that this hyperactivity will eventually cause desensitization of the HPA axis and can lead to HPA hypoactivity in adulthood (Dempster et al., 2021). In those with a history of ACEs, it is common to see allostatic load, a stress disorder associated with deviations from homeostasis, in conjunction with structural and hormonal changes (McEwan, 2007). ACEs can cause permanent alterations and damage to the brain.

3. ACEs and Autonomic Activity

Given the connection between ACEs and chronic stress as well as the effect stress can have on the brain, it is useful to identify potential physiological variables that could serve as biometrics for nervous system dysregulation. A non-invasive way to investigate the relationship between adversity and mental and physical health is to examine physiological activity patterns of the autonomic nervous system in healthy control subjects and in subjects who are suffering from mental and/or physical illness. The autonomic nervous system is part of the peripheral nervous system and is composed of two parts, the sympathetic and parasympathetic divisions. The sympathetic division is activated in response to arousing stimuli and is colloquially known as the ‘fight or flight’ system. Activation of this system is marked by increases in blood pressure, heart rate and sweat activity and decreases in digestive processes (Waxenbaum et al., 2021). The parasympathetic division is activated in times of rest and is often referred to as the ‘rest and digest’ system. Activation of this system results in decreases in heart rate, blood pressure, and sweat activity and restarting digestion, (Waxenbaum et al., 2021). Some physiological measures that indicate autonomic nervous system activity include but are not limited to electrodermal activity (EDA), heart rate (HR), and heart rate variability (HRV).

EDA, the activity of sweat glands located just under the surface of the skin, is a widely used metric of autonomic nervous system arousal (Boucsein, 2012). As an indicator of sweat activity, it can be used as a measure of sympathetic nervous system activation. Thus, EDA has been identified as a physiological marker of emotional distress (Westphal et al., 2017). A common method of obtaining EDA is to measure changes in skin conductance (SC), which is achieved by passing a low voltage electric current between two electrodes placed on the surface of the skin and measuring the resulting change in current between them (Braithwaite et al., 2013).

HR, the number of times your heart beats in one minute, can be computed from various data sources but is most commonly detected via electrocardiogram (ECG), or measurements of the changes in the voltage across one's chest. ECG peaks indicate when the electrical events leading to a contraction of the heart muscle occur. HR values were used to calculate HRV, which is a physiological measure of changes in cardiac rhythm over time. This study utilizes the Root Mean Square of Successive Differences (RMSSD), which is a time-domain measure of HRV that measures the variance in time intervals between subsequent heartbeats. RMSSD is the predominant metric used to assess vagally-based changes in beat-to-beat interval, (Shaffer & Ginsberg, 2017). The vagal nerves are the principal nerves in the parasympathetic nervous system. These changes in cardiac rhythm are influenced by changes in the sympathetic and parasympathetic branches of the autonomic nervous system as well as interactions between the heart and brain, (Clifford et al., 2006). The average range of RMSSD in healthy adults is 19-71 milliseconds (Nunan, 2010). HRV within healthy ranges is an indicator of good health and adaptability. Higher HRV is also associated with higher functioning in the prefrontal cortex, (Shaffer & Ginsberg, 2017). Low values of HRV have been shown to relate to myocardial infarction; progression of atherosclerosis; and heart failure (Huikuri et al., 1999). Some studies have also associated low HRV values with coronary artery disease and sudden death (Xhyheri et al., 2012), diabetes mellitus (da Silva et al., 2016), acute and chronic stress (Murray, 2012; Castaldo et al., 2015), metabolic syndrome (Stuckey et al., 2014), depression (Koenig et al., 2016), and bipolar disorders (Bassett, 2015). Furthermore, HRV has been used as a marker of emotional states, with higher HRV marking higher emotion regulation and lower anxiety levels (Choi et al., 2017; Mather & Thayer, 2019).

4. The Current Study

The purpose of the current study was to investigate if certain physiological activity patterns could be early indicators of the adverse health outcomes associated with ACEs that are seen in adulthood. More research is needed to gain a better understanding of how ACEs are linked to long-term negative mental health outcomes and physiology. The hypotheses in this study were as follows: 1) Individuals who score high on the ACEs scale will display higher levels of HR and EDA at baseline than those with low scores, 2) individuals who score high on the ACEs scale will have higher HR and EDA during the stress task than those with low ACEs scores, and 3) Participants in the high ACEs group will have lower overall HRV than those in the low ACEs groups.

II. MATERIALS AND METHODS

Participants

The participants involved in this study were undergraduate students currently enrolled at Augusta University. Participants could have been of any academic classification including Freshman, Sophomore, Junior, Senior, dual-enrolled, or non-degree seeking. Our sample consisted of 97 participants. Using G*power software (Faul, et al., 2007), the number of participants needed to obtain a large effect size (.35) was calculated to determine the number of participants needed for this study. For a large effect size (.35) with an error probability of (.05), a sample size of 89 was recommended (See Appendix A for the G*Power output). Nine participants were added to account for attrition or participants who were EDA non-responders. Participants were recruited through the Augusta University Department of Psychological Sciences undergraduate research participant pool (SONA), through announcements made in undergraduate classes, and through flyers posted on the Summerville and Health Sciences Campuses of Augusta University. Participants may have received course credit or extra credit at the discretion of their professor for their participation.

Participants who self-reported having hyper-or hypohidrosis (excessive or lack of sweat activity), excessively cold hands, or any other skin condition that interferes with sweat gland activity were excluded from participating in the study as these conditions would all affect electrodermal activity readings. Additionally, any student under the age of 18 was not allowed to participate.

Measures

1. **Adverse Childhood Experiences (ACEs) Measure**

ACEs were measured in this study using the Adversity and Abuse Items from the Harvard Second Generation Study Questionnaire (Morrill et al., 2019). This is a modified form of the ACEs Scale originally published by Felitti et al. (1998). It contains 26 multipart questions including (in various combinations) confirmation or denial of an experience, age of that experience, identification of others involved in that experience, frequency of that experience, open-ended descriptions of the experience, and the level of stress caused by the experience. See Appendix B for a complete list of questions included in the measure. Participants completed the measure through the survey software utilized by Augusta University, Qualtrics.

2. Stroop Test

The Stroop Test is a commonly used cognitive processing task in which participants are shown a word (a color name) in a colored font and asked to report what font color the word is written in. The purpose is to see if participants can successfully differentiate between the words they are reading and the colors they are seeing. The Stroop Test has been shown to raise autonomic activity and can be used as a stressor for research (Gersak et al., 2012). For this study, the Stroop Test is a neutrally stressful stimulus taken while psychophysiological markers are being measured.

3. Demographic Questionnaire

The demographic questionnaire in this study is a researcher created survey asking students to identify the following information: Age, gender identity, race/ethnicity, socioeconomic status, if they have sought psychological treatment in the last 12 months, if they have been prescribed psychotropic medication in the last year, frequency of alcohol use, frequency of tobacco use, and frequency of electronic cigarette or vape use.

4. Psychophysiological Recording

The psychophysiology markers in this study are all measured on a BIOPAC MP160 (Biopac Systems, Inc., Santa Barbara, CA). EDA and HR will be recorded on a BIOPAC MP160 unit at a sampling rate of 2000Hz, an acquisition rate of 1000 samples per second (2Khz), and gain of x5000. These acquisition parameters are based on suggestions provided by Braithwaite et al. (2013). EDA was measured by placing pre-gelled electrodes on the intermediate phalanges of the index and middle fingers of the participant's non-dominant hand and secured using medical tape. Biopac AcqKnowledge software was used to analyze the EDA patterns. Heart rate (HR) was measured using a three-lead ECG smart amplifier with electrodes being placed on the right and left wrists and the left ankle. From HR, HRV was calculated using Biopac's proprietary software, AcqKnowledge (v. 5.0).

Procedure

The study was approved by the Augusta University Institutional Review Board. Participants signed up for a 30-minute time slot through SONA. Participants met the researcher in room GE3042 of the GE Building on the Health Sciences Campus of Augusta University. A researcher verbally ensured the participant did not meet any of the exclusion criteria, then reviewed the informed consent document with the participant. If the participant gave their consent to participate, the researcher obtained their signature on the informed consent document (ICD), then signed it themselves. The participant was given a copy of the ICD to retain, and the other was filed in a locked drawer of GE3042. Once consent was obtained, the researcher attached the participants to the BIOPAC with electrodes lined with isotonic gel. The participants then sat still and quiet for two minutes to obtain the participants' baseline EDA and HR. After this, the participants completed the Stroop Task on the computer per the researcher's instructions, while EDA and HR readings were being recorded. The participants were then disconnected from the BIOPAC. Participants then completed the ACEs questionnaire and filled out their demographic information. Finally, the researcher debriefed the participant and gave them contact information for the Augusta University Student Counseling Center. Students were automatically awarded credit through the participant pool management software (SONA).

III. RESULTS

Participants

Participants were 97 currently enrolled Augusta University students. The mean age of the participants was 20.77 (*SD* = 3.87). The sample was 73.2 % women, 24.7% men, and 2.1% transgender/gender non-binary. Participants' race was classified as White (37.1%), Black/African American (30.9%), Hispanic/Latinx (8.2%), Asian/Pacific Islander (15.5%), and other (8.2%). Table 1 contains descriptive statistics for these demographic characteristics. SES was recorded as a measure of self-perceived social standing and as the participants' perception of how well off they are. The measure of self-perceived social standing was on a scale of 1-10 with 10 being the highest standing with a mean of 5.39, a standard deviation of 1.59, and a range of 2-10. The measure of how well-off participants are was also on a scale of 1-10 with 10 being the most well-off with a mean of 5.43, a standard deviation of 1.56, and a range of 1-9.

Table 1

Demographic Variables

Variable		Mean	Standard Deviation	Range	Frequencies
Age		20.77	3.87		
Race		2.27	1.32		
	White/Non-Hispanic (1)				37.1%
	Black/African American (2)				30.9%
	Hispanic/Latinx (3)				8.2%
	Asian/Pacific Islander (4)				15.5%
	Other (5)				8.2%
Gender		1.29	.50		
	Woman (1)				73.2%
	Man (2)				24.7%
	Transgender/Gender Non-Binary (3)				2.1%

Approximately twenty-two percent (22.3%) of the participants reported that they had been prescribed psychotropic medications during the last 12 months. Table 2 shows the type and frequency of the medications reportedly prescribed to the participants. Participants were asked about therapy attendance in the last 12 months, and 45.7% indicated that they had attended therapy within the last year.

Table 2

Drug Class	*N*	Frequency
Antidepressants	3	14.29%
Anxiolytics	8	38.09%
Combined Medications (depression, anxiety, ADHD, psychosis)	10	47.62%

B. Analyses

Three participants were removed as their EDA or HR scores were three or more standard deviations away from the mean, so they were considered outliers. Thus, 94 participants were included in the analyses. Additionally, 10 participants were excluded only from the HRV analysis as their HRV data was more than 3 standard deviations away from the mean and therefore were considered outliers. They were not excluded from EDA and HR analyses as their data was not considered to be outliers for those variables. The independent variable was ACEs score which is typically analyzed as a categorical variable with 3 groups. In this study, ACEs scores were divided into 3 groups (Group 1: 1-5; Group 2: 6-10; Group 3: 11-26). The dependent variables were EDA, HR, and HRV. A MANOVA was not indicated here because the DVs are not correlated. Table 3 displays the correlation coefficients between the variables. Thus, in order to determine if these data show evidence of a significant difference between ACEs score groups and the 2 timepoint measures of EDA, HR, and HRV, three separate ANOVAs were conducted.

Table 3

Correlation Coefficients Between Dependent Variables

	Variable (Time)					
Variable (Time)	EDA(T1) *r* (*p*)	EDA(T2) *r* (*p*)	HR(T1) *r* (*p*)	HR(T2) *r* (*p*)	HRV(T1) *r* (*p*)	HRV(T2) *r* (*p*)
EDA(T1)		.957* (<.001)	.038 (.714)	.106 (.308)	-.004 (.970)	-.069 (.533)
EDA(T2)			.040 (.702)	.087 (.403)	.034 (.761)	-.054 (.627)
HR(T1)				.669* (<.001)	-.147 (.184)	.051 (.648)
HR(T2)					-.039 (.726)	.107 (.335)
HRV(T1)						.491* (<.001)

C. Results

1. ACEs Score and EDA

A two-way repeated measures ANOVA was conducted to assess the impact of ACEs score and EDA during the two timepoints. Table 4 contains descriptive statistics for ACEs groups and EDA. There was a significant difference in time 1 and time 2 within all three groups, $F(1, 91) = 91.71$, $p = <.001$, indicating that the Stroop Task was a sufficient stressor. However, there was no statistically significant difference found between the groups and time 1 EDA, $F(2, 91) = .276$, p = .760. There was also no significant difference between the 3 ACEs groups and their EDA during time 2, $F(2, 91) = .750$, $p = .475$ (see Figure 1).

Table 4

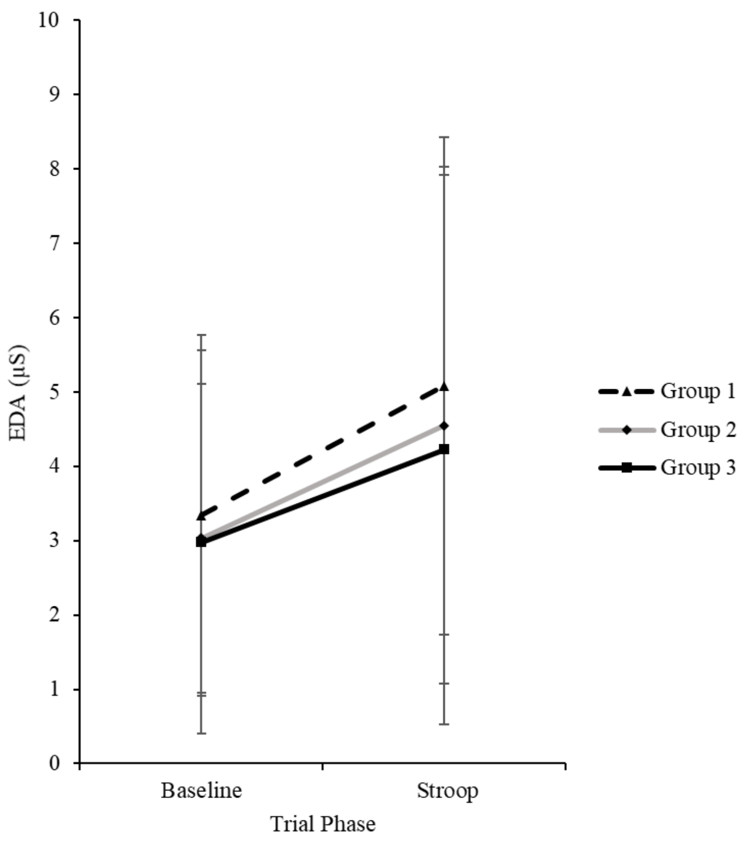
ACEs and EDA

	EDA (T1)		EDA (T2)	
	M (*SD*)	95% CI	*M* (*SD*)	95% CI
Group 1	3.34 (2.43)	[2.30, 4.38]	5.08 (3.34)	[3.52, 6.65]
Group 2	3.03 (2.07)	[2.31, 3.76]	4.55 (3.47)	[3.46, 5.65]
Group 3	2.98 (2.58)	[2.17, 3.76]	4.23 (3.69)	[3.01, 5.45]

N = 94

Figure 1

Mean EDA values for three ACES groups at baseline and during the Stroop task



2. ACEs Score and HR

A two-way repeated measures ANOVA was conducted to investigate the impact of ACEs score on HR during two separate time points. Time 1 was a 2-minute baseline and time 2 was during the Stroop task. Table 5 contains descriptive statistics for ACEs group and HR. There was a significant effect of time, with time 1 and time 2 being significantly different within all groups, F (1, 91) = 62.38, p = <.001. However, there were no significant differences between the 3 ACEs groups and time 1 HR, F (2, 91) = .116, p = .890. There was also no significant difference between ACEs groups and their HR during time 2, F (2, 91) = .592, p = .555 (see Figure 2).

Table 5

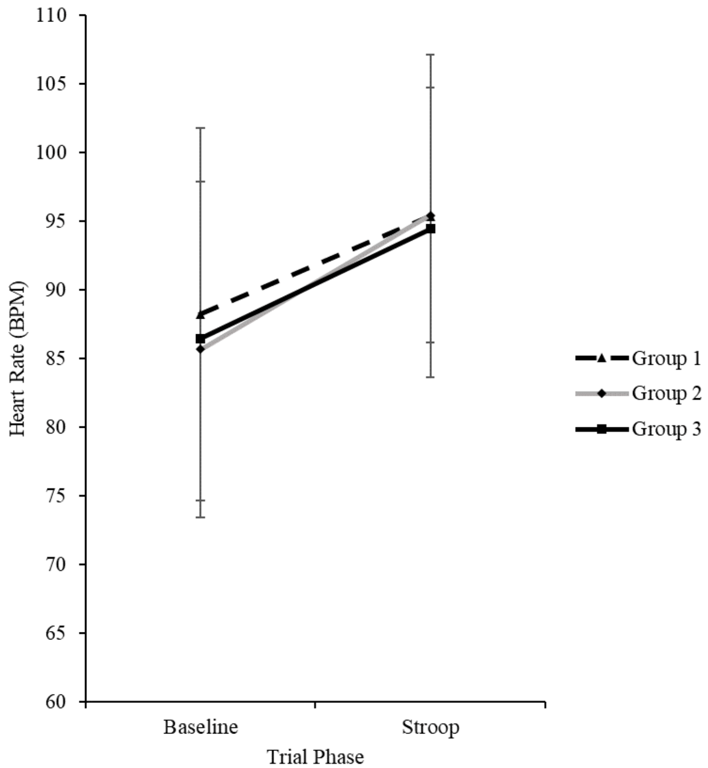
ACEs and HR

	HR (T1)		HR (T2)	
	M (*SD*)	95% CI	*M* (*SD*)	95% CI
Group 1	88.25 (13.58)	[82.51, 93.98]	95.39 (12.26)	[90.70, 100.08]
Group 2	85.67 (11.76)	[81.66, 89.68]	95.46 (9.26)	[92.18, 98.73]
Group 3	86.47 (13.87)	[82.00, 90.93]	94.45 (10.99)	[90.80, 98.11]

N = 94

Figure 2

Mean HR values for three ACES groups at baseline and during the Stroop task



3. **ACEs and HRV**

A two-way repeated measures ANOVA was conducted to investigate the impact of ACEs score on HRV during two separate time points. Time 1 was a 2-minute baseline and time 2 was during the Stroop Task. Table 6 contains descriptive statistics for ACEs groups and HRV. There was no significant difference within groups at time 1 and time 2, F (1, 80) = 6.98, p = .010. There were also no significant differences between ACEs groups and their recorded HRV during time 1, F (2,80) = 2.227, p = .109. Furthermore, there were no significant differences between ACEs groups and their time 2 HRV, F (2,80) = 1.781, p = .175 (see Figure 3).

Table 6

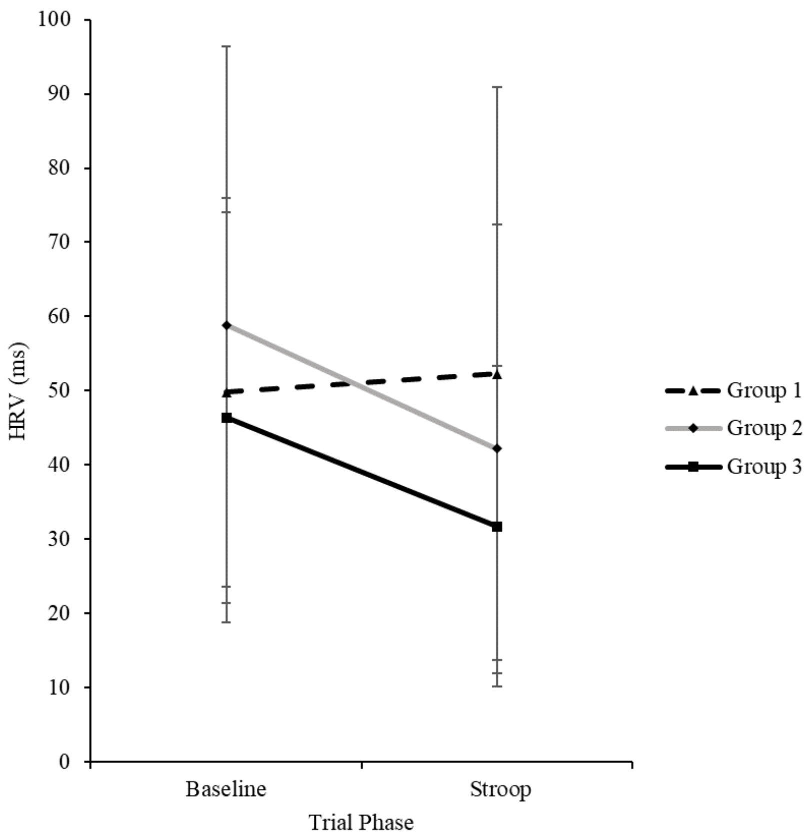
ACEs and HRV

	HRV (T1)		HRV (T2)	
	M (*SD*)	95% CI	*M* (*SD*)	95% CI
Group 1	49.81 (26.13)	[33.75, 65.88]	52.32 (38.63)	[37.67, 66.97]
Group 2	58.87 (37.44)	[48.45, 69.30]	42.18 (30.27)	[32.68, 51.69]
Group 3	46.42 (27.60)	[34.48, 58.35]	31.76 (21.62)	[20.88, 42.64]

N = 83

Figure 3

Mean HRV values for three ACES groups at baseline and during the Stroop task



IV. DISCUSSION

The purpose of this study was to investigate if there was a connection between an individual's ACEs score and their autonomic activity including HR, EDA, and HRV. Participants' physiology was measured during a baseline period of rest and again during a stressful task. We hypothesized that participants in the high ACEs group would have significantly higher EDA and HR during the baseline reading. Additionally, we hypothesized that participants in the high ACEs group would display higher EDA and HR during the Stroop Task than participants in the low ACEs groups. Finally, we hypothesized that participants in the high ACEs group would have lower HRV than those in the lower ACEs groups. None of these hypotheses were supported by the data found. There were no significant differences between the low and high ACEs groups on any physiological measures at either time 1 or time 2.

Limitations

There were several limitations in this study. The sample consisted of college aged adults with a mean age of 20, so the sample was majority very young adults. Additionally, the sample was majority women so gender differences could not be examined. Future studies could benefit from obtaining a sample with a more diverse age range and gender distribution to examine differences in these groups. Participants were also asked if they had been prescribed psychotropic medications in the last year, however, there was no measure of their medication status at the time of data collection, so there was no way to investigate differences in currently medicated participants and those not on medication. Another limitation was that HR and EDA were only measured during one session. Participants may have had external factors on the day of data collection that skewed their results including using more or less of a substance like caffeine, running late, or having trouble finding the lab that could have caused extra stress, or there could have been warmer weather outside. Consumption of caffeine can stimulate sympathetic nervous system activity, including increasing heart rate and body temperature. Caffeine can also increase feelings of nervousness and anxiety, (Hancock & McKim, 2018). Additionally, higher temperatures affect the sympathetic nervous system and can cause alterations in HRV, (Okada & Kakehashi, 2014). Future research could benefit from having participants come in for multiple measurement sessions and taking an average of those sessions to get a more accurate baseline. Additionally, HRV is most accurate when measured over a longer period of time. This study utilized the minimum allowable time for HRV recording because of time constraints and to avoid participant discomfort. Future studies could take longer measurements and may get a more accurate evaluation of a participant's HRV. Lastly, the ACEs scoring could be more informed moving forward. This study defined ACEs score as the raw number of experiences a participant indicated. However, there is an item on the ACEs scale that allows a participant to indicate the stress level felt with each experience. This could be used in the future to create an ACEs score that may be a more accurate representation of the participants' actual experience of trauma.

Future Research

Future research could look further into the data including examining the difference between the participant's baseline physiology and their physiology during the Stroop Task as a variable. This difference score could provide insight into whether high

ACEs scoring individuals' physiology shifts or increases more drastically under stress than those with lower ACEs scores. This information could be beneficial to the overall picture of the strain that stressful events put on those individuals in their daily lives. The researcher has that data and will be running those analyses as the next step in this research. Additionally, future studies could benefit from looking at the specific ACEs that individuals report and investigating physiological differences between those individuals. For example, if a person responds to the ACEs measures regarding a chaotic or unstable household, it would be interesting to examine if their physiology is different than a participant who responds to the measures regarding peer bullying.

V. SUMMARY

The results of this study contribute to the larger body of research regarding ACEs and physical health. Importantly, replication of this study with a larger, more diverse sample size could potentially display important demographic differences. Additionally, given the lack of significance seen in this study, it warrants further research into ACEs and physiology to determine when and how differences may be seen between individuals. Understanding the role that ACEs play in overall health, as well as physiological markers of anxiety and stress, could be used to inform clinicians of the dangers their clients may face physically and mentally if ACEs are known to be present. Additionally, as future studies clarify the link between early life trauma and physiology, it can add to the explanations of trauma's long term health outcomes. In summary, this topic requires further exploration to increase the knowledge and understanding of these complex issues.

VI. REFERENCES

Afifi, T. O., Enns, M. W., Cox, B. J., Asmundson, G. J. G., Stein, M. B., & Sareen, J. (2008). Population attributable fractions of psychiatric disorders and suicide ideation and attempts associated with adverse childhood experiences. *American Journal of Public Health*, *98*(5), 946-952. https://doi.org/10.2105/AJPH.2007.120253

Bassett, D. (2015). A literature review of heart rate variability in depressive and bipolar disorders. Austral. N. Z. *J. Psychiatry 50*, 1–9. doi: 10.1177/0004867415622689

Boucsein, W. (2012). *Electrodermal activity.* New York: Plenum Press.

Braithwaite, J. J., Watson, D. G., Jones, R., and Rowe, M. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. *Psychophysiology 49*, 1017–1034.

Bryan, R. (2019). Getting to why: Adverse childhood experiences' impact on adult health. *The Journal for Nurse Practitioners*, *15*(2), 153-157. doi: 10.1016/j.nurpra.2018.09.12

Castaldo, R., Melillo, P., Bracale, U., Caserta, M., Triassi, M., and Pecchia, L. (2015). Acute mental stress assessment via short term HRV analysis in healthy adults: a systematic review with meta-analysis. *Biomed. Signal Process. Control 18*, 370–377. doi: 10.1016/j.bspc.2015.02.012

Chapman, D. P., Whitfield, C. L., Felitti, V. J., Dube, S. R., Edwards, V. J., & Anda, R. F. (2004). Adverse childhood experiences and the risk of depressive disorders in adulthood. *Journal of Affective Disorders*, *82*, 217-225. https://doi.org/10.1016/j.jad.2003.12.013

Choi, K.-H., Kim, J., Kwon, O., Kim, M. J., Ryu, Y. H., and Park, J.-E. (2017). Is heart rate variability (HRV) an adequate tool for evaluating human emotions? A focus on the use of the International Affective Picture System (IAPS). *Psychiatry Res. 251*, 192–196. doi: 10.1016/j.psychres.2017.02.025

Clifford, G., Azuaje, F., and McSharry, P. E. (2006). *Advanced Methods and Tools for ECG Data Analysis*. Norwood, MA: Artech House.

da Silva, A. F., da Costa de Rezende Barbosa, M. P., Vanderlei, F. M., Christofaro, D. D., and Vanderlei, L. M. (2016). Application of heart rate variability in diagnosis and prognosis of individuals with diabetes mellitus: systematic review. Ann. Noninvasive Electrocardiol. 21, 223–235. doi: 10.1111/anec.12372

Dempster, K., O'Leary, D., MacNeil, A., Hodges, G., & Wade, T. (2021). Linking the hemodynamic consequences of adverse childhood experiences to an altered HPA axis and acute stress response. *Brain, Behavior, and Immunity, 93,* 254-263. doi: 10.1016/j.bbi.2020.12.018

Felitti, V., Anda, R., Nordenberg, D., Williamson, D., Spitz, A., Edwards, V., Koss, M., & Marks, J. (1998). Relationship of childhood abuse and household dysfunction to many leading causes of death in adults: The adverse childhood experiences study. *American Journal of Preventive Medicine, 14*(4), 245-258. https://doi.org/10.1016/j.amepre.2019.04.001

Gersak, G., Ogorevc, J., & Drnovšek, J. (2012). Stroop test – A reference stimulus for psychophysiological measurements?

Hancock, S. & McKim, W. (2018). *Drugs and behavior: An introduction to behavioral pharmacology.* Pearson Education.

Hege, A., Bouldin, E., Roy, M., Bennett, M., Attaway, P., & Reed-Ashcraft, K. (2020). Adverse childhood experiences among adults in North Carolina, USA: Influences on risk factors for poor health across the lifespan and intergenerational implications. *International Journal of Environmental Research and Public Health, 17*(8548). https://doi.org/10.3390/ijerph17228548

Heron, M. (2019). Deaths: Leading causes for 2017. *National Vital Statistics Report, 68*(6). https://www.cdc.gov/nchs/data/nvsr/nvsr68/nvsr68_06-508.pdf

Herzog, J. I., & Schmahl, C. (2018). Adverse childhood experiences and consequences on neurobiological, psychosocial, and somatic conditions across the lifespan. *Frontiers in Psychiatry, 9*(420). https://doi.org/10.3389/fpsyt.2018.00420Huikuri, H., Mäkikallio, T., Airaksinen, K., Mitrani, R., Castellanos, A., and Myerburg, R. (1999). Measurement of heart rate variability: a clinical tool or a research toy? J. Am. Coll. Cardiol. 34, 1878–1883. doi: 10.1016/S0735-1097(99)00468-4

Karatekin, C. (2017). Adverse childhood experiences (ACEs), stress and mental health in college students. *Stress and Health, 34*, 36-45. https://doi.org/10.1002/smi.2761

Koenig, J., Kemp, A., Beauchaine, T., Thayer, J., and Kaess, M. (2016). Depression and resting state heart rate variability in children and adolescents - a systematic review and metaanalysis. Clin. Psychol. Rev. 46, 136–150. doi: 10.1016/j.cpr.2016.04.013

Martín-Higarza, Y., Fontanil, Y., Méndez, M., & Ezama, E. (2020). The direct and indirect influences of adverse childhood experiences on physical health: A crosssectional study. *International Journal of Environmental Research and Public Health, 17*(8507). https://doi.org/10.3390/ijerph17228507

McEwan, B. (2013). The brain on stress: Toward an integrative approach to brain, body, and behavior. *Perspectives on Psychological Science, 8*(6), 673-675. doi: 10.1177/1745691613506907.

Merrick, M., Ford, D., Ports, K., Guinn, A., Chen, J., Klevens, J., Metzler, M., Jones, C., Simon, T., Daniel, V., Ottley, P., & Mercy, J. (2019). Vital signs: Estimated proportion of adult health problems attributable to adverse childhood experiences and implications for prevention — 25 States, 2015–2017. *Morbidity and Mortality Weekly Report, 68*(44), 995-1005.

Morrill, M. I., Schulz, M. S., Nevarez, M. D., & Preacher, K. J. (2019). Assessing within- and between-family variations in an expanded measure of childhood adversity. *American Psychological Association, 31*(5), 660-673. http://dx.doi.org/10.1037/pas0000691

Murray, A. (2012). Examining heart rate variability and alpha-amylase levels in predicting PTSD in combat-experienced marines (Ph.D. thesis). Alliant International University, Alhambra, CA, United States.

Okada, M. & Kakehashi, M. (2014). Effect of outdoor temperature on changes in physiological variables before and after lunch in healthy women. *International Journal of Biometrology, 58*(9), 1973-1981. doi: 10.1007/s00484-014-0800-1

Shaffer, F., and Ginsberg, J. (2017). An overview of heart rate variability metrics and norms. Front. Public Heal. 5:258. doi: 10.3389/fpubh.2017.00258

Stuckey, M., Tulppo, M., Kiviniemi, A., and Petrella, R. (2014). Heart rate variability and the metabolic syndrome: a systematic review of the literature. Diabetes. Metab. Res. Rev. 30, 784–793. doi: 10.1002/dmrr.2555

Westphal, M., Aldao, A., & Jackson, C. (2017). Emotion dysregulation in comorbid posttraumatic stress disorder and substance use disorders: A narrative review. *Military Psychology*, *29*(3), 216-220.

Xhyheri, B., Manfrini, O., Mazzolini, M., Pizzi, C., and Bugiardini, R. (2012). Heart rate variability today. Prog. Cardiovasc. Dis. 55, 321–331. doi: 10.1016/j.pcad.2012.09.001

VII. APPENDIX A

[8] -- *Friday, April 15, 2022 -- 15:29:52*

F tests – Linear multiple regression: Fixed model, R^2 increase

Analysis:	A priori: Compute required sample size		
Input:	Effect size f^2	=	0.15
	α err prob	=	0.05
	Power (1–β err prob)	=	0.95
	Number of tested predictors	=	1
	Total number of predictors	=	10
Output:	Noncentrality parameter λ	=	13.3500000
	Critical F	=	3.9634721
	Numerator df	=	1
	Denominator df	=	78
	Total sample size	=	89
	Actual power	=	0.9503703

VIII. APPENDIX B

HARVARD
SECOND GENERATION
STUDY

Adversity and Abuse Items from the 2016 Harvard Second Generation Study Questionnaire

1. The following questions are about things that sometimes happen during childhood. When answering, please think back to your own childhood, that is, from birth through 18 years of age.

While you were growing up, before you turned 19, were your parents ever separated or divorced?

- ○ Yes
- ○ No → **Go to question 2**

1a. During your childhood, how many times did this happen?

[ ] Times

1b. What age or ages were you when this happened?

[ ] Years old

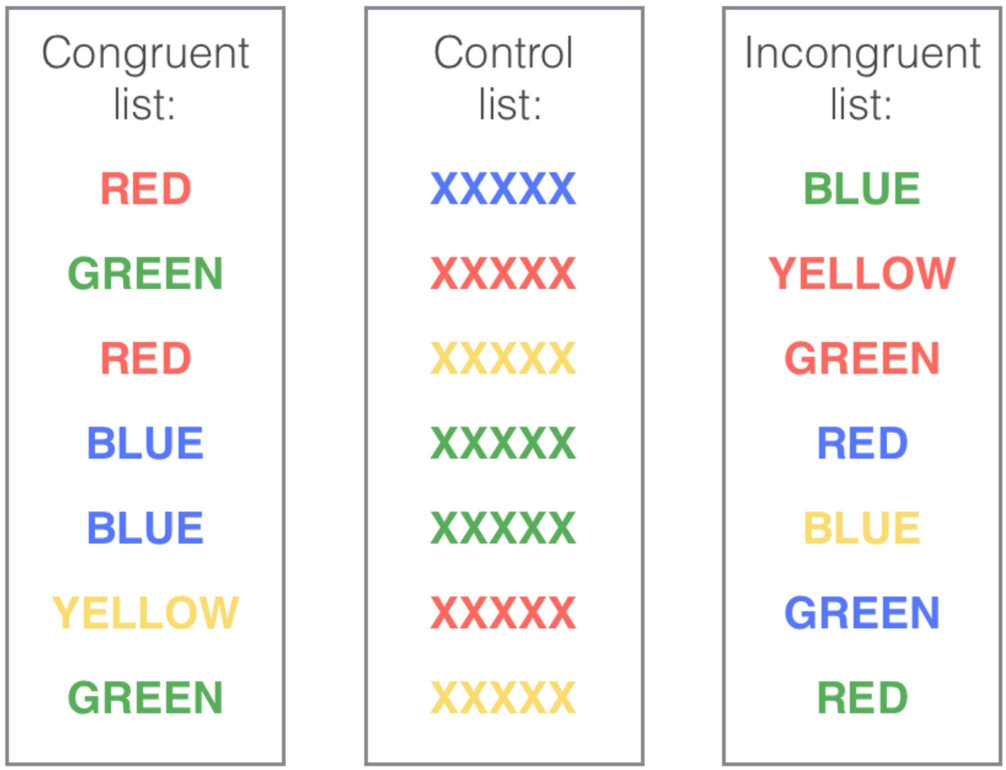
1c. Overall, how stressful was this for you?

- ○ Not at all
- ○ A little
- ○ Somewhat
- ○ Very
- ○ Extremely

1

For a complete list of items, please see: http://dx.doi.org/10.1037/pas0000691

IX. APPENDIX C



X. APPENDIX D

Please answer the following as honestly and completely as possible.

1. Please indicate your gender.
    a. Man
    b. Woman
    c. Transgender/Gender non-binary
    d. Different Identity (Please state)

2. How do you identify your race/ethnicity?
    a. Native American/First Nation
    b. Black/African American
    c. Hispanic/Latinx
    d. White, non-Hispanic/Latinx
    e. Asian/Pacific Islander
    f. Different Identity (Please state)
3. Have you been prescribed psychotropic medications in the last year? (i.e., antidepressants, anti-anxiety medications, etc.)
4. If yes, what type of medication? (Select all that apply.)
    a. Anti-Depressant medications
    b. Anti-anxiety medications
    c. Anti-psychotic medications
    d. Attention deficit medications (i.e., Adderall, Vyvanse, etc.)
5. Have you sought psychological treatment (i.e., counseling, therapy, etc.) in the last year?
6. In the past year, how many times have you used the following?
    a. Alcohol:
        i. Never
        ii. Once or twice
        iii. Monthly
        iv. Weekly
        v. Daily or almost daily

b. Tobacco Products:

  i. Never
  ii. Once or twice
  iii. Monthly
  iv. Weekly
  v. Daily or almost daily

c. Vapes/Electronic Cigarettes:

  i. Never
  ii. Once or twice
  iii. Monthly
  iv. Weekly
  v. Daily or almost daily

7. Think of a ladder representing where people stand in their communities. People define communities in different ways; please define it in whatever way is most meaningful to you. At the top of the ladder are people who have the highest standing in their community. At the bottom of the ladder are the people who have the lowest standing in their community. Where would you place yourself on this ladder? There are 10 rungs on the ladder, numbered from 1 (those with the lowest standing) to 10 (those with the highest standing); please select the number associated with the rung on the ladder which represents where you think you stand at this point in your life, relative to other people in your community. Which rung of this ladder represents where you think you stand at this point in your life, relative to other people in your community?

a. 1 (Those with the lowest standing)
b. 2
c. 3
d. 4
e. 5
f. 6
g. 7
h. 8
i. 9
j. 10 (Those with the highest standing)

8. Think of a ladder representing where people stand in the United States. At the top of the ladder are those who are the best off - those who have the most money, the most education, and the most respected jobs. At the bottom are people who are the worst off - who have the least money, the least education, and the least respected jobs or no job. The higher up you are on this ladder, the closer you are to the people at the very top; the lower you are, the closer you are to the people at the very bottom. Where would you place yourself on this ladder? There are 10 rungs on the ladder, numbered from 1 (those who are the worst off) to 10 (those who are the best off); please select the number associated with the rung on the ladder which represents where you think you stand at this point in your life, relative to other people in the United States. Which rung of the ladder represents where you think you stand at this point in your life relative to other people in the United States?

a. 1 (Those who are the worst off)

b. 2

c. 3

d. 4

e. 5

f. 6

g. 7

h. 8

i. 9

j. 10 (Those who are the best off)