THE UNIVERSITY OF CHICAGO

PSYCHOPHYSIOLOGICAL RESPONSES TO THE DISTRESS OF OTHERS

A DISSERTATION SUBMITTED TO

THE FACULTY OF THE DIVISION OF THE SOCIAL SCIENCES

IN CANDIDACY FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

BY

STEPHANIE DIMITROFF

CHICAGO, ILLINOIS

JUNE 2018

To my grandmother, Jenny, and my father, William.

TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGEMENTS

COMMITTEE MEMBERS

Greg J. Norman (Chair)

University of Chicago, Department of Psychology

Jean Decety

University of Chicago, Department of Psychology

Brian J. Prendergast

University of Chicago, Department of Psychology

David A. Gallo (Reader)

University of Chicago, Department of Psychology

SPECIAL THANKS

Upon my first visit to The University of Chicago in February 2013, I knew this institution was a special place. The University of Chicago is a rightful intellectual paradise, with gothic buildings, sprawling ivy, and libraries overflowing with leather-bound books on every topic imaginable. Walking around this campus has provided daily inspiration and as such this work has been greatly enriched by the thousands of individuals who give life to this wonderful academic community, which I have had the immense pleasure of calling my home for these past five years.

Of the individuals who populate this campus, I have had the great luck of meeting and working with some of the most intelligent, kind and curious people I have ever known. My first and biggest thank you goes to my advisor, Dr. Greg Norman. In my very first email to Greg, I wrote: "Should I get the opportunity to work with you, it would be difficult to not show up to the lab everyday with excited motivation." Despite the inherent difficulties and stresses of graduate school, Greg has made that promise easy to keep. Greg's mentorship was dedicated, crafted, encouraging, caring and motivating. I am forever grateful for all the time and effort that has gone into helping me as an academic, and ultimately, as a person. I have looked forward to Friday mornings for these past five years – my meeting time with Greg. Every meeting was full of zeal and enthusiasm for science, and I always left invigorated about research.

Greg's influence has not only been academic, but in creating a lab environment that truly felt like a family. Our SPNL environment has always been full of laughter and camaraderie. My "family" here in Chicago has consisted of the members of the Social Psychophysiological and Neuroendocrinological Laboratory, past and present. These members include Dr. Greg Norman, Kelly Faig, Karen Smith, Dr. Elizabeth Necka, Dr. John Morris, Dr. Kasey Van Hedger, Kenneth Onishi, Frederica Rockwood and Colleen Wohlrab. This work has been influenced by each one of them. I need to especially thank Kelly and Karen, who started this adventure with me together, and who have made this experience all the more special. They have been the best support network, excellent collaborators, but most importantly, great friends. A big thank you also goes to Ethan Harrod, whose help made Study 2 possible. Dr. Jean Decety, Dr. Brian Prendergast and, Dr. Marc Berman have also all played critical roles in guiding my thinking on the studies in this dissertation.

Before coming to Chicago, I was part of Dr. Jens Pruessner's lab at McGill University. The lab members at the time were incredibly helpful to me as an undergraduate, and I thank them all for their time in supervising me. I would especially like to thank Dr. Pruessner for believing in me as an undergraduate, and spending the time to meet with me and develop my ability to think like a scientist. I would also like to thank the many people who have provided me with support through all this. Laura Dimitroff, Anda Dragomir and Bryan Ciampa; thank you for your unconditional friendship. To my mother, Nonna, and family in Ottawa for cheering me on and encouraging me throughout these past five years, and to my cousin David for holding up his promise.

Importantly, I would like to thank my father. For as far back as my memory can be trusted, I can remember my father teaching me how to read, how to do math, and how to build things. As I got older (but long before I could actually grasp these topics) he introduced me to concepts like genetics and organic chemistry. I could tell he was excited about these things, and so naturally, I got interested. I never felt pushed into science. Instead, because of my father, I felt pulled towards it. He gave me the gift of curiosity, a gift that makes every day more exciting and meaningful. To this day, he is still a constant source of inspiration. He has spent many hours on the phone with me, patiently (and enthusiastically!) listening while I speak at length about the minute details of my projects and has supported me, every time, through all the varied hurdles of graduate school. This dissertation would never have been written had it not been for his endless effort in raising me into who I am today.

And finally, this dissertation is dedicated to my Nana. I spent the vast majority of my undergraduate hours studying at her kitchen table. She encouraged me daily, made me coffee and cakes, and read every assignment I wrote. I wish she could read this dissertation, because I know she would read it cover to cover. This one is for her.

ABSTRACT

The ability to detect and respond to others' distress is supported by the dynamic interaction of cognitive, affective, and psychophysiological processes that allow the perception of distress in one individual to directly change the affective state of another, a phenomenon referred to as emotional contagion. While research over the past three decades has elucidated a number of mechanisms supporting emotional contagion, a considerable amount of work will be necessary in order to fully understand the inter-individual and psychophysiological factors that moderate the "contagiousness" of emotions across different contexts. In this dissertation, I explore the influence of observing others' distress on psychophysiological processes and test potential moderating factors. In Study 1, I investigated the role of individual differences in empathy on the psychophysiological response to viewing others not only experiencing, but also recovering from stress. Results show that viewing stress in others leads to distinct physiological changes in the observer, independent of empathy levels, even when viewing individuals in the stress recovery condition. Findings also suggest that emotional judgements of others were related to cardiac reactivity, such that heart rate deceleration in observers was positively related to their judgements of anxiety levels of stressed individuals. In Study 2, I examined how individuals respond when observing a third-party be socially rejected. Results from this study illustrate that individuals who observe someone undeservingly reject another individual, will punish the rejecter by administering significantly louder sound blasts and choosing to give them significantly less money within the context of a dictator game, consistent with models of altruistic punishment. Furthermore, altruistic punishment was positively moderated by the participant's history of being exposed to bullying, and cardiac reactivity while viewing the bullying episode. Taken together, these findings contribute to our understanding of how

psychophysiological states of one individual can affect those of another, and how contextual and psychological variables help explain variation in how individuals respond to distress in others.

CHAPTER ONE: GENERAL INTRODUCTION

Our happiness and wellbeing as humans is dependent on having a social network that meets our needs (Baumeister & Leary, 1995). To ward off feelings of isolation we must actively engage in fulfilling interactions with family, friends and romantic partners. If we fail to do so, and our social needs are chronically unmet, feelings of loneliness may develop (Hawkley & Cacioppo, 2010). In a large sample of American adults, 8.4% reported never or rarely receiving social and emotional support, which was correlated with a tenfold increase in the odds of being dissatisfied with life (Strine et al., 2009). In addition to lower life satisfaction, feelings of perceived loneliness have been related to a host of negative health outcomes including increased systolic blood pressure (Hawkley, Thisted, Masi, & Cacioppo, 2010), increased hypothalamic pituitary adrenocortical activity (Adam, Hawkley, Kudielka, & Cacioppo, 2006), altered immunity (Pressman et al., 2005), increased risk of developing dementia (Holwerda et al., 2014) and a higher incidence of mortality (Holt-Lunstad et al., 2010). Loneliness has also recently been shown to be related to self-reported cold symptoms after a viral challenge (LeRoy, Murdock, Jaremka, Loya, & Fagundes, 2017). On the other hand, being in possession of healthy and stable relationships can lead to beneficial health outcomes, reduce stress reactivity and promote overall wellbeing and longevity (Thoits, 2011; Uchino, Cacioppo, & Kiecolt-Glaser, 1996; Waldinger & Schulz, 2010; Yang et al., 2016; Zeidner, Matthews, & Shemesh, 2015).

While it is clear that unmet social needs wreak havoc on both physical and mental health, what currently remains unclear is what types of inter-individual differences predispose some individuals to have rich and fulfilling social lives. Why do some individuals navigate their social environments with apparent ease, while others see it as a maze of considerable difficulty? Understanding the internal state of others is one crucial determinant to these processes. It is a basic unit of all social interactions. It is the capacity to decode the signals produced by another independent nervous system, and make meaning from them. More specifically, it is the ability to empathize. Our very survival as a species has depended upon our ability to communicate with one another and attend to the needs of our offspring and related kin (Decety, Norman, Berntson, & Cacioppo, 2012). Empathic processes allow us to understand others and share experienced feelings (Decety & Jackson, 2004). Empathy is a computationally complex form of inference, that relies on a combination of observation, memory, knowledge and reasoning to gain insights into the thoughts and feelings of others (Decety et al., 2012; Ickes, 1997). Given our inherent sociality, empathy towards others' feelings can alter our behavior, as virtually all of our actions are either directed towards others or in response to others (Batson, 1990). As such, our ability to empathize with others plays a crucial role in all of our relationships.

Empathy can facilitate the sharing of both positive and negative emotion, and individuals differ in how they react in response to observed emotions in others. In particular, I am interested in the sharing of distress. The observation of pain or suffering in others can generate aversive responses in observers that ostensibly serve to increase motivation to assist a group member in need (Hein, Silani, Preuschoff, Batson, & Singer, 2010). This type of response, often referred to as empathic concern, is a significant predictor of the size of one's social support group (Kardos, Leidner, Pléh, Soltész, & Unoka, 2017), which supports the notion that empathic abilities are important for maintaining social connections, especially close ones. The adaptive value of responding to distress in others is embedded in the evolutionary history of the human species (Decety, 2011; Decety et al., 2012; Eisenberg & Strayer, 1987). Cooperative group living has been necessary for the reproductive success of early humans, and the strength of the group would be compromised if any member was unwell (Alexander, 1974). Thus, responding and tending to distressed individuals is likely to have conferred an evolutionary advantage to the robustness of the group. Furthermore, to maintain healthy relationships, one must be a cooperative partner and react to distress in others with adequate emotional or social support. In fact, providing social support to others may actually confer its own health benefits to the donor (Brown, Nesse, Vinokur, & Smith, 2003), increase overall well-being (Thomas, 2010) and help one with emotional regulation to cope with one's own distress (Ochsner, 2017). More importantly, providing social support can greatly reduce the distress being experienced by others. Chronic pain patients who were more satisfied with their levels of received social support rated their pain as being less intense, and had less depressive moods (Lopez-Martinez, Esteve-Zarazaga, & Ramirez-Maestre, 2008). Individuals who received social support reported experiencing less pain during in an experimental pain induction (Brown, Sheffield, Leary, & Robinson, 2003; Roberts, Klatzkin, & Mechlin, 2015) and had higher survival rates after a cancer diagnosis (Sarma et al., 2018). Experiencing traumatic life events like a cancer diagnosis or a divorce, can lead to personal growth, and this effect is amplified if one receives adequate social support (Prati & Pietrantoni, 2009; Schroevers, Helgeson, Sanderman, & Ranchor, 2010). Mice have also been shown to exhibit less pain-related behavior when frequented by a same-sex conspecific (Jeon et al., 2010) and mice displayed significantly lower levels of pain sensitivity in response to peripheral nerve injury when pair-housed as compared to those who were socially isolated (Norman et al., 2010). Similarly, consolation behavior, or affiliative contact which appears to reduce an individual's distress, has also been demonstrated in chimpanzees (Fraser, Stahl, & Aureli, 2008), bonobos (Clay, de Waal, Hare, Beck, & Ivan, 2013), gorillas (Cordoni, Palagi, & Tarli, 2006), corvids (Fraser, Bugnyar, Knight, Schaumburg, & Heinrich, 2010), canids (Cools, Van Hout, & Nelissen, 2008) and elephants (Byrne et al., 2008). Albeit the adaptive nature of responding to the distress of others, there exists an optimal level of responding, and if it is not regulated, such responding can become disadvantageous. If one is very susceptible to the stress of others, stress contagion can result in chronic stress, which has known negative health consequences (Juster, McEwen, & Lupien, 2010). This can be especially detrimental for those who find themselves in the position of being a caregiver (Lovell & Wetherell, 2011). Furthermore, if one is too affected by the negative emotions of others, one's ability to then help would be impeded by one's own personal distress (Carrera et al., 2013) . Finally, being overly sensitive to the distress of others can result in misattribution of the emotions of others, perceiving distress in its absence, which may then perturb social communication (Duncan & Barrett, 2007; Hertel, Schütz, & Lammers, 2009). Taken altogether, understanding the psychophysiological response mechanisms to the distress of others is not only vital for our understanding of how it relates to positive social outcomes, but also how it can veer too far and become maladaptive.

Responding to the distress of others is a multi-step process that relies on synergistic psychophysiological systems. First, the observer must recognize that the individual in question is experiencing distress. This recognition must then be followed by a psychophysiological reaction in the observer. This psychophysiological reaction will then play a role in the motivation to engage in a response. The first component, namely the skilled recognition of the emotional states of others, is termed empathic accuracy (Ickes, 1997). The second component is largely reliant on emotional contagion (Hatfield, Cacioppo, & Rapson, 1994), which refers to the automatic sharing of emotional states between two individuals. Emotional contagion is a core component of empathy, that facilitates our understanding of others, as with little exerted effort we can mount an emotional response that is a reflection of the person with whom we are interacting (Hatfield et al., 1994). This capacity is one that is rooted deep in evolutionary history, as its existence has been found in other animals, such as pigs (Goumon & Špinka, 2016), rats (Ben-Ami Bartal, Decety, & Mason, 2011), chickens (Edgar, Lowe, Paul, & Nicol, 2011) and ravens (Osvath & Sima, 2014).

Given the psychophysiological nature of emotions (Cacioppo, Bernston, Larsen, Poehlmann, & Ito, 2000), the experience and regulation of emotion is dependent on the state of the nervous system (Porges, Doussard-Roosevelt, & Maiti, 1994). As such, both empathic accuracy and emotional contagion can be studied as physiological processes. There are significant benefits of studying these processes through a biological lens, as it can provide the researcher with continuous data that is subject-specific, as it fluctuates through time. There have been a number of studies that have investigated the physiological reactions in response to the distress of others. For example, viewing images of others enduring painful situations has been shown to elicit increased activity within the anterior cingulate cortex (ACC); activity which correlates with subjective ratings of pain (Jackson, Meltzoff, & Decety, 2004). Activity in the ACC has also been shown in response to viewing vignettes of others in social distress, namely embarrassing situations (Krach et al., 2011). Watching individuals experiencing a painful procedure has been shown to induce an increase in activity in the facial muscles associated with frowning, and create a short-lived deceleration in heart rate (Lamm, Porges, Cacioppo, & Decety, 2008). While these studies, and many other likes them, provide some insight into how we respond to distress signals in others, as of yet, they do not create a cohesive picture.

In the following dissertation, I investigated psychophysiological responses to the distress of others, specifically focusing on three aspects; empathic accuracy, emotional contagion and behavior. Activity within the autonomic nervous system was measured as it provides temporally-rich data that is implicated in emotional functioning and indicative of higher-order neurobiological processes (Norman, Berntson, & Cacioppo, 2014). The specific measures I use are inter-beat intervals (IBI) of the heart, which is the time in milliseconds between each heartbeat, and respiratory sinus arrhythmia (RSA), as measured by variation in heart rate over the respiratory frequency band, which is a relatively pure measure of parasympathetic nervous system activity (Bernston et al., 1997). By monitoring IBI, I was able to measure phasic changes in heart rate in response to relevant stimuli, that corresponded to either cardiac acceleration or deceleration. Cardiac acceleration has been classically associated with a defense response (Graham & Clifton, 1966; Hare & Blevings, 1975), and is often elicited by experimentally induced stress (Haynes, Gannon, Orimoto, O'Brien, & et al, 1991; Kirschbaum, Pirke, & Hellhammer, 1993). Cardiac deceleration is associated with an orienting response (Öhman, Hamm, & Hugdahl, 2000) that facilitates sensory intake, and is often elicited in reaction to aversive and/or unpleasant stimuli (Adenauer, Catani, Keil, Aichinger, & Neuner, 2010; Brouwer, van Wouwe, Mühl, van Erp, & Toet, 2013; Hagenaars, Roelofs, & Stins, 2014). Such phasic changes in IBI has been shown to be vagally mediated, and are likely affected by neural processing in the amygdala and prefrontal cortex (Ruiz-Padial, Vila, & Thayer, 2011) . Furthermore, RSA is a measure of vagally mediated variability in heart rate, and is thought to be an index of central-peripheral neural feedback mechanisms (Thayer & Lane, 2000). Higher RSA has been associated with greater flexibility to environmental demands, stronger attentional control and better self-regulatory abilities. As such, RSA is an important measure in relation to emotion regulation and responding (Butler, Wilhelm, & Gross, 2006; Porges et al., 1994; Thayer & Lane, 2000). Resting RSA provides information about the flexibility or rigidity of an individual's ability to organize physiological resources in response to changing environmental demands. Phasic decreases in RSA are often representative of increased stress levels, and can be used as an index of stress when compared to resting levels (Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012).

Broadly construed, the aim of the present project is to endeavor to understand how different individuals react when observing distress in others, and what kinds of inter-individual differences (psychological and physiological) relate to these responses. To do so, I have designed two studies. The first study is an investigation into the emotional contagion of stress. For this study, I recorded videos of multiple individuals experiencing varying levels of stress, and then had participants come to the lab and watch these videos, and rate how anxious they believed each speaker to be. Continuous physiological data was collected from both speakers in videos and observers. Data from this study provide insight into empathic accuracy (how well participants were able to identify anxiety in speakers) and emotional contagion (physiological changes shared by speaker and observer). The second study examines how individuals react to observing someone be socially rejected. We led participants to believe that they had two other partners in the experiment, and then had them witness one of these fictitious participants be rejected by the other. The main outcome variable of interest was their behavior in response, namely, would they punish the bully? Physiological activity was monitored in participants while they observed the rejection. In both studies, I examined how empathy, and psychopathy (the lack thereof of empathy) interacted with results. Altogether, these two studies allowed me to investigate how individuals react to the distress of others, from recognition of distress, up until the behavioral response, and how inter-individual differences, physiological responses and psychological dispositions affect various levels of empathic functioning.

CHAPTER TWO: PHYSIOLOGICAL DYNAMICS OF STRESS CONTAGION

INTRODUCTION

The ability to share emotional information with one another is an essential part of the human experience; one that not only adds to the richness of life, but is crucial for the coordination of social interactions. Emotional expressions are readily observable by others, for example, through facial expressions, postures, overt behaviors, and fluctuations in vocal tone (Bänziger & Scherer, 2005; Ekman & Paul, 1993). To successfully navigate the social environment, one must be adept at rapidly discerning the meaning of these emotional cues, and know how and when to appropriately react to them. While this is generally accomplished with apparent little effort, developing a mechanistic understanding of how emotional cues are processed in the receiver is no simple task as it involves the deciphering of dynamically changing facial expressions, postures, gestures, vocal tones and language, in near real time and in the context in which they occur (Bänziger, Grandjean, & Scherer, 1979). One such proposed mechanism for the facility of emotional understanding is through emotional contagion, the automatic transmission of emotional states between individuals (Hatfield et al., 1994). The ability to "catch" aspects of another person's emotions may serve as a relatively fast and effective way of understanding another individual's affective state, which likely enhances one's ability to be a successful agent in a highly complex and dynamic social environment (Decety & Lamm, 2009). However, individual differences in empathy can create disparities in the ability to accurately understand the meaning of these expressions in others (Decety & Jackson, 2004). Because the negatively valenced emotions, and their related physiological correlates, associated with stress have been clearly demonstrated to have deleterious health consequences when present chronically (McEwen & Gianaros, 2010), it is important to understand how these emotions are perceived and transmitted to others. The existence of stress contagion may indicate an additional pathway to these deleterious health consequences (Warren et al., 2013). Furthermore, determining how individuals transfer negative affect from one to another is fundamental to our understanding of social interactions.

Emotions, like all psychological processes, are fundamentally psychophysiological in nature. The physiological response to a stimulus is central to all affective processes (Cacioppo, Bernston, Larsen, Poehlmann, & Ito, 2000; Norman, Berntson, & Cacioppo, 2014). Given the physiological nature of emotional cognition, one way of extracting information from the affective sharing process, is through physiological investigations. This type of investigation allows for objective measurement of internal changes that occur in response to the emotional state of another individual, allowing the researcher to compare that response to state of the target. Work by Buchanan et al. (2011) was among one of the first to demonstrate that the experience of stress may be physiologically “contagious” between individuals. In their study, “observers” were panelists in the Trier Social Stress Test (TSST), a task which has been repeatedly shown to elicit a robust stress response in which “speakers” give an impromptu speech to a panel of judges (Kirschbaum et al., 1993), and markers of stress reactivity (alpha-amylase and cortisol) were measured in both the observers and the speakers. Cortisol release in the observers was proportional to the release in speakers, and amount of alpha amylase and cortisol release was related to empathy levels of the observers. These findings elegantly demonstrate that the physiological markers of a stress response not only change in the individual experiencing stress, but in the individual observing it. Similar work was later conducted by Engert et al. (2014), who had observers watch either a romantic partner or a stranger complete the TSST via a one-way mirror or video. Findings from this study revealed a positive association between cortisol release in the speaker and observer, with the strongest association being between romantic partners via one-way mirror. Similarly, the transmission of negative affect and associated psychophysiological response has been studied in the context of mother and infant interactions, with findings indicating that mothers' stress responses can impact autonomic reactivity in their infants (Waters, West, & Mendes, 2014). Evidence for the contagion of stress also exists in rats; rats living with stressed conspecifics exhibited a shift in autonomic activity towards sympathetic prevalence, and an increase in plasma corticosterone levels (Carnevali et al., 2017). Altogether, there is strong evidence that observing another individual in distress creates physiological disturbances in the observer.

While progress has been made in understanding some of the physiological underpinnings of stress contagion, much remains to be known. Given the health consequences associated with caregiver stress (Lovell & Wetherell, 2011), and the less intense, but more frequent social situations where empathic stress or stress contagion are likely to occur (Westman, 2001), more detailed understanding of the social, psychological, and physiological mechanisms that allow for the spread of stress across individuals is likely to have important implications for health. Furthermore, stress contagion represents an important avenue of research in empathy, as being susceptible to stress contagion may convey a benefit to our ability to understand the distress of others.

The experience of stress is typically associated with changes in the activity of both the hypothalamic pituitary adrenal (HPA) axis and the autonomic nervous system (ANS), and different types of stressors can result in different patterns of activation (Bernston et al., 1994; Seery, 2011). Under circumstances of intense or chronic stress, both of these stress response pathways have been found to be associated with a variety of unfavorable health outcomes

(McEwen & Gianaros, 2010). Thus, while stress contagion has been shown to affect the HPA axis in adults (Buchanan et al., 2011; Engert et al., 2014), further research is necessary to better understand how the autonomic nervous system (ANS) reacts in adults. Understanding the extent to which viewing stressed others affects ANS activity in the observer not only provides information regarding potential pathways to later pathology, it also allows for a better understanding of the underlying affective processes due to the increased temporal resolution of ANS responses that cannot be gleaned by monitoring HPA axis activity alone. The HPA axis, being a hormonal system, takes minutes to be engaged, while changes in autonomic activity can be measured on a second-to-second time scale (Cacioppo, 1994). Determining the latency and magnitude of the ANS response to watching others experiencing stress may provide vital information regarding the particular emotions being induced in the watcher. Moreover, evaluating the co-variation of cardiac responses between the speaker and observer may provide information regarding the ability of the observer to track the emotional state of the individual experiencing stress.

Another important aspect of observing distress in others, is empathic accuracy, or the ability to discern the emotional experience of another (Ickes, 1997; Levenson & Ruef, 1992). Much of the literature on the social cognition of others has focused on the mechanisms involved in processing of others' emotions, and not at how well these attempts to understand the internal states of others fare (Zaki & Ochsner, 2011). Being able to discern when another is in need of help depends on the ability to first detect that someone is experiencing significant levels of distress. It is surely clear how this ability is critical for navigating one's social environment, and research has elucidated its importance in a number of areas including relationship outcomes (Côté & Miners, 2006; Gleason, Jensen-Campbell, & Ickes, 2009; Maneta, Cohen, Schulz, &

Waldinger, 2015), psychological adjustment (Simpson et al., 2011), successful negotiation (Elfenbein, Foo, White, Tan, & Aik, 2007) and leadership skills (Rubin, Munz, & Bommer, 2005).

In the current study, I seek to determine individual psychophysiological responses to viewing videos of strangers who have been exposed to varied levels of stress, the extent to which this response is associated with that of the participant in the video, how well participants are able to assess the state of the speaker and whether any of these outcomes are dependent on levels of empathy, or lack of empathy as seen in psychopathy, in the observer. To do so, I created a stimulus set of videos of people speaking without exposure to a social stressor, during a social stressor, and after experiencing a social stressor, during which I monitored speakers' cardiac autonomic activity. I then measured the corresponding cardiac responses of participants who viewed these videos. Previous work in adults has solely had participants watch others perform the TSST. While the current study utilizes this approach, I also included speakers who were less obviously stressed, in the "Post Stress" videos. Everyday life is rife with these affective puzzles of determining who is stressed when the circumstances make the emotional state of others somewhat ambiguous. Thus, the inclusion of this "Post Stress" group is intended to represent this type of encounter. Participants were also asked to rate the anxiety levels of every speaker that they watched, thus allowing for the assessment of their empathic accuracy. Furthermore, previous work has not explored the timing of such effects, that is, how long it takes observers to physiologically react to viewing stress. Understanding the time dynamics of these changes is important, as it may reveal inter-individual differences in the way individuals perceive and respond to the emotions of others on a second to second basis. For example, appropriate timing of interpersonal synchrony has been shown to be related to feelings of affiliation for others (

Cacioppo et al., 2014; Hove & Risen, 2009). I recorded neurocardiac activity on a beat-to-beat basis, and was thus able to measure physiological co-variation occurring in the speaker and the observer with relatively high temporal resolution. The current study also included many different target speakers, which allowed me to determine whether these effects were person specific or generalizable across individuals, as previous work has only examined stress contagion from one speaker to one observer.

I hypothesized that observers would show larger psychophysiological reactions to the "Stress" and "Post Stress" videos as compared to the "No Stress" videos, and that subjective anxiety ratings made for those videos will be higher. I also hypothesized that levels of empathy would interact with these physiological responses to viewing others who are stressed, in that empathetic individuals would have greater physiological reactivity in response to viewing stress, and individuals high in psychopathy would have the least physiological reactivity in response to viewing stress. I hypothesized that "Stress" and "Post Stress" videos would create more time-varying changes in heart rate in observers, as compared to "No Stress" videos, given their increased salience, and potential to attract attention. Finally, I hypothesized that empathic accuracy would be positively related to empathy and negatively related to psychopathy.

METHODS

Stimulus Set Generation (Part A)

Participant Speakers Twenty-one TSST-naïve participants were selected to be included in the stimulus set of videos. All participant provided their written informed consent as approved by the University of Chicago Institutional Review Board.

Procedure Participant speakers completed a number of self-reported measures, including the Questionnaire of Cognitive and Affective Empathy (QCAE; Reniers, Corcoran, Drake, Shryane, & Völlm, 2011) and the Psychopathic Personality Inventory-Revised: Short Form (PPI-R: SF; Lilienfeld & Widows, 2005). A set of additional questionnaires were completed for secondary analyses. Once completed, participant speakers were fitted with surface electrodes for the measurement of the electrocardiogram. Participant speakers were then given a standard grey shirt to wear and instructed to sit in a chair that was in front of a wall draped with a white sheet. E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA) was be used to display experimental instructions on a 39" LED TV facing the participants. A high-resolution webcam (Logitech HD Pro Webcam C920) was fitted above the TV facing the participant, and a microphone was installed on a table next to them (Audio-Technica ATR2500-USD Cardioid Condenser USD Microphone). Once seated, the video recording of participant speakers began. The first section of the experimental task was a five-minute long rest period to obtain the participants' physiological baseline. Following the rest period, individuals completed a series of tasks, some of which included a neutral speech about their morning routine or a description of their house (No Stress), the TSST (Stress) or a post-stress neutral speech on one of the two topics listed earlier (Post Stress).

Participants completing a neutral speech were given a prompt (either to talk about their morning routine or to give a detailed description of the interior of their house), were told they had two minutes to think of what they will say, and were then instructed to speak for three minutes.

Participants who completed the TSST were told that they were accused of cheating on the GRE and had to defend themselves, were given two minutes to prepare a speech, and then had to speak for three minutes while the experimenter watched over them with a neutral expression, taking notes. As is standard for this stress induction paradigm (Kirschbaum et al., 1993), participants were also told behavioral analysts would later judge the video on their speech, intelligibility, clarity and quality of content.

Participants who completed a "Post Stress" speech first performed a TSST, followed by a ten-minute rest period, followed by a neutral speech describing either their morning routine or the interior of their house. Their neutral speech, which was given during a state of stress recovery, was the one used for the experiment. See Figure 1.1 for a visual representation of the methods for Part A.

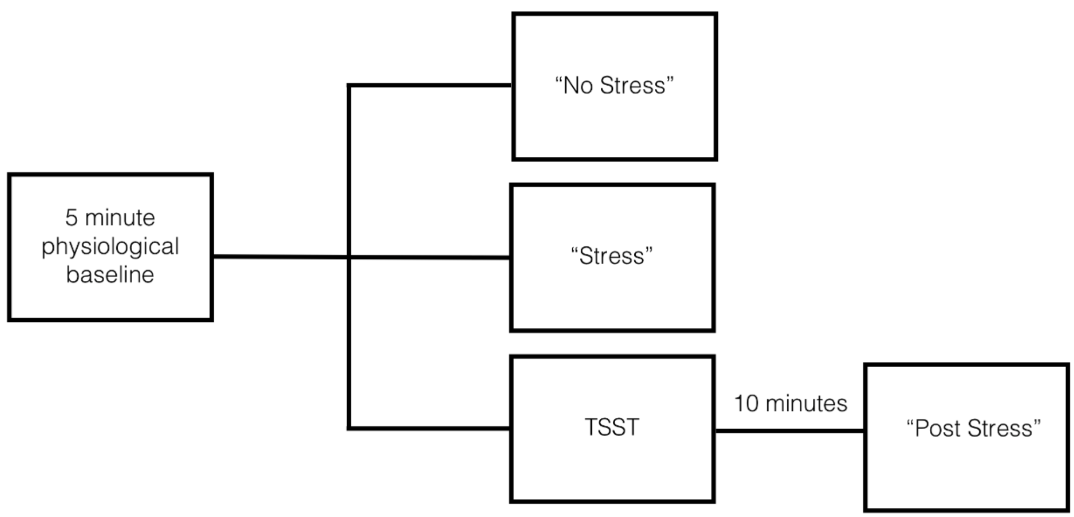

Figure 1. 1 Schematic of methods used for stimulus set generation

Video Generation Videos of 21 participants were edited and selected to be part of the stimulus set for the second part of the study (referred to as Part B). All videos were edited using AVS Video Editing software. Videos were framed so that only participants' faces and their bodies from the elbows up were visible. Each video was edited down to one minute in duration. In all, the 21 videos were comprised of seven "No Stress" videos, seven "Stress" videos and seven videos of "Post Stress". Physiological data was analyzed with HRV Analysis 3.1.0 (Mindware, Gahanna, Ohio). Videos were chosen from the larger stimulus set based on a number of criteria. Videos with any audiovisual aberrations, or unclear speech were excluded. Speakers whose ECGs revealed any abnormal recurrent ecoptic heartbeats were also excluded. Once unusable data/videos were excluded, videos were chosen based upon cardiac responses. Both "Stress" and "Post Stress" videos were comprised of the seven speakers who exhibited the strongest cardiac responses during their respective experimental phase, while ensuring a balanced number of males and females were selected. "No Stress" videos were comprised of the seven speakers who remained closest to their physiological baseline, while ensuring selected videos represented a balanced gender distribution. The videos were then randomly ordered and compiled into an E-Prime script. Two different orderings were made. In each E-Prime script, there were three blocks, each composed of seven videos of differing types.

Part B

Participant Observers Seventy participants were recruited to be observers. All participants provided their written informed consent as approved by the University of Chicago Institutional Review Board. Participants were instructed to refrain from consuming caffeine or participating in strenuous activity for two hours prior to participation.

Procedure Observers first completed the same questionnaires that were administered to participants who were part of the stimulus set. Once fitted with surface electrodes participants were seated in front of a 39" LED TV. Before the start of the videos, participants sat quietly for collection of a five-minute physiological baseline. Participants then watched the 21 videos embedded into the E-Prime script described above in “Video Generation”, in one of two random orderings. Following each video, a pop-up screen asked: “How anxious was the person in the video?” where participants indicated their answers on a visual analog scale with a mouse. Between each video there was a 10 second fixation cross, and between each block of seven videos there will be a three-minute break. See Figure 1.2 for a schematic of the procedure for Part B.

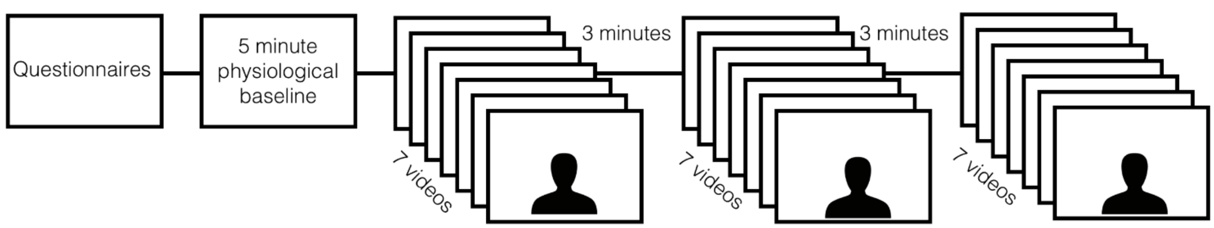

Figure 1. 2 Schematic of procedure for participants in Part B

Physiological measures A standard lead II configuration was used for obtaining the electrocardiogram (ECG) on both speakers and observers. ECG data were used to assess inter-beat interval (time in ms between heart beats) and high frequency heart rate variability (HF-HRV) as indexed by respiratory sinus arrhythmia (RSA). HF-HRV is a rhythmic fluctuation of heart rate in the respiratory frequency band, and has been demonstrated to be a fairly pure index of parasympathetic nervous system activity. RSA was derived from the ECG using spectral analysis that isolated the respiratory band (0.12 – 0.42 Hz) by filtering out both low- and mid-frequency heart rate variability. The inter-beat interval series was time sampled at 4 Hz (with interpolation) to yield an equal interval time series. The time series was detrended (second-order polynomial), end tapered and submitted to a fast Fourier transform. RSA magnitude was indexed by the natural log of the heart period variance within the respiratory frequency band (in ms^2). Data were collected using a BioNex two-slot mainframe (Mindware Technology, Gahanna, OH) which was connected to a personal computer. The sampling rate of the electrocardiogram (ECG) signal was 1000 Hz. Analysis of the ECG signal was performed using Mindware Technology's HRV software, Version 3.10. Visual inspection and manual editing of the data was completed to ensure proper removal of all artifacts and ectopic beats (Bernston et al., 1997). RSA and IBI were scored minute by minute.

Measure of empathy and psychopathy Dispositional empathy was assessed with the Questionnaire of Cognitive and Affective Empathy (QCAE; Reniers et al., 2011), a standardized method of obtaining trait levels of both cognitive and affective empathy. Psychopathy was evaluated using the Psychopathic Personality Inventory-Revised: Short Form (PPI-R:SF; Lilienfeld & Widows, 2005), a well-known and validated self-report measure.

Video type and observer physiological activity To calculate average inter-beat interval (IBI) and RSA for each video type, Mindware HRV software was used to determine the average IBI and RSA of each observer during each video viewed. To calculate the average IBI and RSA of each video type, the 7 IBI values and the 7 RSA values for each video type were averaged. All IBI and RSA data were baseline corrected using each individual observers' first five minutes of baseline. Thus, five IBI values, representing the average IBI for the first five minutes of baseline, was averaged and used as the denominator to create baseline corrected IBI values. RSA was baseline corrected in the same manner. Repeated measures ANOVAs were used to compare IBI and RSA of observers during the viewing of three different video categories. All multiple comparisons performed were Bonferroni corrected at $p < 0.05$.

Anxiety Ratings Anxiety ratings were made on a visual analog scale by observers, which were converted into numerical scores that ranged from 0 to 100. To calculate the average anxiety score of each video type, the seven anxiety scores for each video type were averaged. Repeated measures ANOVAs were used to compare anxiety ratings of observers during the viewing of three different video categories. All multiple comparisons performed were Bonferroni corrected at $p < 0.05$.

Time series analysis For each video, a time series analysis was performed using the IBI of the speaker and the observer. This was done by correlating the IBI signal from the speaker and lagged IBI signal of the observer, for lags between 0 to 20 seconds. By lagged signal, I refer to one where the first k (k between 0 to 20 seconds) data points of the signal (the IBI values) are discarded, and the rest of the signal is shifted backwards by the same amount in time. The process is akin to holding one signal (speaker's IBI) untouched, while sliding the other signal (observer's IBI) backwards in time in steps of one beat, and calculating the Pearson correlation between the speaker's signal and the lagged signal from the observer at each lag as it increases from 0 seconds up to 20 seconds. Twenty seconds were chosen as the maximum lag in order to maximize our potential to quantify longer latencies, while keeping the data analytic approach practical. The correlation between the two signals typically increases as the lag gets longer up to an optimal lag, and then begins decreasing again when the introduced lag gets too long. I shifted the speaker's signal by the lag because the physiological response from the cause of the contagion (speaker) must temporally precede the physiological response of the observer. That optimal lag where the speaker's and the observer's IBI signals are correlated maximally, as well as the size of the correlation at the optimal lag were compared to the zero-lag correlation (zero-lag correlation is simply the Pearson's correlation between the IBI signals of speaker and observer with no lag, which is used to adjust the correlations at other lags as a baseline correction), was then quantified for each observer and video. The sliding (lagging and correlating) of signals analyses was performed using custom MATLAB R2014a (The MathWorks, Natick, MA, USA) scripts. The optimal lags associated with the maximum correlation between signals was calculated using the MATLAB function 'findpeaks', where the criteria for the correlation peak was that it had to be largest over all of the lags, as well as least 0.01 larger than its values at the previous and the next lag. For every combination of speaker and observer, a maximum correlation (Pearson's *r*) was found, as well as the lag (seconds) at which this maximum correlation occurred.

RESULTS

Part A

Two matched pair t-tests revealed the 14 speakers who completed the TSST (speakers in "Stress" and "Post Stress" conditions), experienced a significant decrease in IBI, $t(13) = 8.49$, $p < 0.01$, $d = 2.27$ ($M = 844$ ms at baseline to $M = 653$ ms during TSST), and a significant drop in RSA, $t(13) = 2.80$, $p = 0.02$, $d = 0.75$ ($M = 6.27$ at baseline to $M = 5.39$ during TSST) from baseline to TSST. Physiological data within each one-minute clip was analyzed in two repeated measures one-way ANOVAs to test for differences in IBI and RSA of speakers. The percent change in IBI of speakers was significantly different based on video type, $F(2, 18) = 15.51$, $p < 0.01$ (see Figure 1.3. IBI) as it was lower in "Stress" videos compared to "No Stress" videos, $t(12) = 6.63$, $p < 0.01$, and lower in "Post Stress" videos compared to "No Stress" videos, $t(12) = 2.76$, $p =$

0.03. “Stress” videos had a lower percent change in IBI compared to “Post Stress” videos but the difference did not pass Bonferroni correction, $t(12) = 2.50$, $p = 0.04$. The difference in percent change in RSA of speakers was trending based on video type, $F(2, 18) = 2.59$, $p = 0.10$.

Part B

Mean IBI A one-way repeated measures ANOVA found a significant main effect of video type on baseline corrected IBI of observers during video viewing, $F(2, 124) = 32.13$, $p < 0.01$. IBI was higher when viewing “Stress” videos than when viewing “No Stress” videos, $t(62) = 4.25$, $p < 0.01$, or “Post Stress” videos, $t(62) = 7.66$, $p < 0.01$, and IBI was also higher when viewing “No Stress” videos compared to “Post Stress” videos, $t(62) = 3.93$, $p < 0.01$ (see Figure 1.4). Dispositional empathy, affective empathy, cognitive empathy and psychopathy of observers did not produce significant interactions ($p > 0.05$) when added as covariates into this model (see Supplemental Materials).

Mean RSA A one-way repeated measures ANOVA found no significant main effect of video type on baseline corrected RSA of observers during video viewing, $F(2, 124) = 1.78$, $p = 0.17$ (see Figure 1.5). Dispositional empathy, affective empathy, cognitive empathy and psychopathy of observers did not produce significant interactions ($p > 0.05$) when added as covariates into this model (see Supplemental Materials).

Anxiety ratings A one-way repeated measures ANOVA found a significant main effect of video type on anxiety ratings of the speakers made by the observers, $F(2, 124) = 50.55$, $p < 0.01$. Speakers in “Stress” videos were rated as significantly more anxious than speakers in “No Stress” videos, $t(62) = 8.93$, $p < 0.01$, and “Post Stress” videos, $t(62) = 6.12$, $p < 0.01$. Speakers in “Post Stress” videos were rated as significantly more anxious than speakers in “No Stress” videos, $t(62) = 3.75$, $p < 0.01$ (see Figure 1.6). Dispositional empathy, affective empathy, cognitive empathy and psychopathy of observers did not produce significant interactions ($p > 0.05$) when added as covariates into this model (see Supplemental Materials).

Correlations between speakers an observers The correlation between mean IBI of observer's while watching videos, and IBI of speakers in videos was not significant, $r(19) = -0.24$, $p = 0.29$. For a visual representation of the relationship between IBI of speakers and observers over the course of the 21 videos, please see Figure 1.7. As can be seen in this graphic, the correlation appears negative for the "Stress" videos, and positive for the "Post Stress" and "No Stress" videos. The correlation between mean RSA of observer's while watching videos, and RSA of speakers in videos was not significant, $r(19) = 0.35$, $p = 0.12$. When relating anxiety ratings to the physiological indices of the speakers, no significant relationship with IBI, $r(19) = -0.35$, $p = 0.12$, or with RSA, $r(19) = -0.28$, $p = 0.22$, was found. When relating anxiety ratings to the physiological indices of the observers during video viewing, a significant relationship with IBI, $r(19) = 0.47$, $p = 0.03$, but not with RSA, $r(19) = 0.24$, $p = 0.91$ was found (see Figure 1.8). This suggests that observer's may have relied on interoceptive cues to judge the anxiety levels of speakers in the videos. To further explore the link between anxiety ratings and IBI of the observers, I examined whether this was related to the sensitivity of each participant's ratings. While I did not have subjective anxiety ratings made by the speakers themselves in order to compare them to the ratings of the observers, I was able to operationalize the "sensitivity" of each participant's ratings by two other means. Firstly, I considered anxiety ratings to be sensitive if they were more highly correlated with the IBI change from baseline in the speakers. Secondly, I computed the Cronbach's alpha for these ratings, which revealed good internal consistency, $\alpha =$

0.81. Thus, given the high level of agreement between observers, I used the average anxiety rating for each video as a secondary means of measuring sensitivity.

The strength of the correlation between IBI of the observer and the anxiety ratings they made predicted the sensitivity of their anxiety ratings based on both physiological change in the speaker, $r(61) = -0.39$, $p < 0.01$ (see Figure 1.9) and on consensus among the observers, $r(61) = -0.27$, $p = 0.03$. Observers' sensitivity scores based on physiological changes were not related with observer empathy, $r(61) = 0.09$, $p = 0.51$, or psychopathy, $r(61) = -0.10$, $p = 0.44$. While sensitivity scores based on observer consensus were not related to observer empathy, $r(61) = 0.10$, $p = 0.42$, they were significantly negatively related to observer psychopathy, $r(61) = -0.30$, $p = 0.02$. For a visual representation of these relationships please see Figure. 1.10.

Maximum physiological correlations and lags to maximum A one-way repeated measures ANOVA found no significant main effect of video type on maximum correlation between the IBI of observer and speaker during video viewing, $F(2, 124) = 0.87$, $p = 0.42$ (see Figure 1.11). Dispositional empathy, affective empathy, cognitive empathy and psychopathy of observers did not produce significant interactions ($p > 0.05$) when added as covariates into this model (see Supplemental Materials). A one-way repeated measures ANOVA found a significant main effect of video type on lag time to reach maximum correlation between the IBI of observer and speaker during video viewing, $F(2, 124) = 10.57$, $p < 0.00$ (See Figure 1.12). Lag times were shorter for "No Stress" videos compared to both "Stress" videos, $t(62) = 4.51$, $p < 0.01$, and "Post Stress" videos, $t(62) = 3.14$, $p < 0.01$ (See Figures 1.13 and 1.14 for visual aid). Dispositional empathy, affective empathy, cognitive empathy and psychopathy of observers did not produce significant interactions ($p > 0.05$) when added as covariates into this model (see Supplemental Materials).

DISCUSSION

The current study sought to expand upon previous literature on the physiological nature of stress contagion, by using a novel video presentation of individuals experiencing varying levels of stress, measuring ANS activity, assessing psychological variables, and empathic accuracy. Existing work on stress contagion in adults has relied on individuals watching others performing the TSST. The TSST is an objectively stressful experience, and thus is not an accurate representation of the nuanced cues one might have to interpret when interacting with someone who is stressed yet not actively involved in a stressor. The results of this study revealed that observing others experiencing or recovering from stress leads to distinct patterns of cardiac activity in the observer. Past research has shown how being exposed to stressed others can lead to feelings of stress in oneself (Westman, 2001), and the current study suggests that the ANS may play a role in how stress responses are transferred. While identifying, and reacting to stress in others is certainly important for sustaining relationships (Butler & Randall, 2012) its deleterious influences on health outcomes is still unknown. Furthermore, not much is known about the dynamics of the response, and how they affect the success of the interaction. As I detail below, the relationship between the physiological stress response of the speaker, and that of the observer is complex. While this study adds to our understanding of how different individuals respond to the stress of others, they open more questions as to which of these responses are the most beneficial to one's social relationships.

Firstly, as predicted, the results demonstrated that observers' physiological activity changed in response to the level of stress in the speakers, however this was only true for IBI, and not for RSA. IBI remained at baseline when viewing others who were not experiencing stress, yet diverged when viewing speakers who were stressed or recovering from stress. Interestingly, the direction of autonomic change in observers when viewing stress and stress recovery was opposing. When viewing speakers who were recovering from stress, I found the expected decrease in IBI (heart rate acceleration) from baseline in observers, which is consistent with the most simplified models of stress contagion that assume the directionality of the stress response is conserved. However, viewing others who were overtly stressed induced an autonomic change in the opposite direction, reflecting cardiac deceleration. Previous literature has demonstrated that, depending on the context of a stressor, cardiac deceleration may be indicative of a 'freezing' stress response (Lang, Greenwald, Bradley, & Hamm, 1993). Cardiac deceleration responses generally occur in situations when no behavioral response is necessary or during periods of information collection (Graham & Clifton, 1966; Sokolov, 1963). Passive stressors, like viewing aversive images or videos, have been shown to elicit cardiac deceleration (Hagenaars et al., 2014; Lang et al., 1993). Thus, while watching "Stress" videos created a physiological change that was in the opposite direction of that in the speakers, this change may still be indicative of a stress response. Indeed, the videos contained aversive content (e.g. watching someone defend themselves from a cheating allegation), and required no action from the observer, thus the context of this "stressor" resulted in cardiac deceleration in the observers. Furthermore, because this result was only seen in IBI and not with RSA, suggests that these changes are likely dually driven by both the sympathetic and parasympathetic nervous systems. Overall, these results highlight the complexity of stress contagion, and demonstrates that the stress response of the observer is not necessarily identical to the response of the speaker, and instead, is likely dependent on contextual factors associated with the situation. As such types of physiological contagion have only recently begun to be empirically examined, the most simple models of contagion, namely synchrony, have taken the central focus (Marsh, Richardson, & Schmidt, 2009; Palumbo et al., 2017). This finding, along with a number of recent studies (Gates, Gatzke-

Kopp, Sandsten, & Blandon, 2015; Liu, Rovine, Cousino Klein, & Almeida, 2013; Timmons, Margolin, & Saxbe, 2015), suggest that emotional contagion should be studied with a broader scope that does not only test for direct mirroring between two individuals. Future work will be necessary to understand the details of how context, relationship and psychological traits can change how stress and its corresponding emotions are physiologically represented when they are transmitted from one individual to the next, and how such effects are related to the parasympathetic and sympathetic nervous systems.

In addition to experiencing physiological changes in response to the video set, observers were also able to accurately judge levels of stress in the speakers. Notably, observers were also capable of differentiating speakers who were in the "No Stress" condition from speakers who were recovering from stress. Importantly, these videos were matched in content, yet the stress-recovery videos ostensibly contain stress cues that allow observers to accurately discern levels of anxiety in the speaker. Future investigations are required to determine which of these cues are necessary for making these judgements (for example would this result hold if only the audio was played?).

When examining whether these anxiety ratings were related to IBI of the speaker, I found that instead, these ratings were related to the IBI of the observers when watching the speaker they were rating. Interestingly this relationship was a positive one, which again reflects the heart rate deceleration that occurred in observers when watching "Stress" videos. As anxiety ratings increased, the IBI of the observers also increased. One potential explanation is that when judging anxiety in others, we tune into our own bodies to make these assessments, as we intuitively know our bodies are being influenced by the anxiety of the target. Some credence is added to this result as the more "interoceptive" a participant was, the better their ratings mapped onto the physiological state of the speaker. Overall, this suggests that interoception may play a role in how we judge emotions in others, and consequently may influence our empathic accuracy; a link that warrants further investigation.

When analyzing IBI linkage between speakers and observers on a second to second level, I observed that the magnitude of the linkage did not differ as a function of the type of video viewed. This analysis was done using a time lag, to determine when in time the maximum correlation between IBI of speaker and observer occurred. Interestingly, there were differences observed in lag time for type of video viewed; with "Stress" videos inciting the longest latency and "No Stress" videos having the shortest latency. Physiological linkage may have taken the most amount of time when watching "Stress" videos because of the complexity of the emotional content, while "No Stress" videos may have taken the least amount of time because of the lack of strong affective cues. Future work should explore this avenue of investigation to determine what the social implications are for faster psychophysiological reactivity in response to others. Given how quickly the complex constellation of emotions of a social interaction may change, recognizing and responding to such changes in a timely manner may shape the course and success of a social exchange.

Empathy was not related to any of the physiological indices measures. While one's dispositional empathy is undoubtedly a factor that affects our reactions to the stress of others (Batson, Fultz, & & Schoenrade, 1987), these data did not find any relationships between our way of measuring empathy (via standardized questionnaire) and our dependent measures (physiological changes, anxiety ratings). This suggests that either the questionnaire we used was not specific enough to measure the type of empathic processes employed by this experiment, or that the physiological measures we analyzed were not related to dispositional empathy. It is also possible that our findings were reflective of basic socio-physiological processing that does not differ within the normal range of empathy that I observed in our participants. I did find one connection with psychopathy, namely that as psychopathic traits increased in participants, their anxiety ratings veered further from the general consensus of participants. Since psychopathy is associated with lesser levels of anxiety, perhaps individuals high in psychopathy were less able to able to recognize anxiety in others, much like individuals with congenital insensitivity to pain are less able at detecting pain in others (Danziger, Prkachin, & Willer, 2006)

Limitations of the current data include the sample that was used, which was mainly composed of undergraduates at the University of Chicago, and thus I do not know if these results would generalize to a more representative sampling of the population. Furthermore, this work was done via video, and thus the ecological validity of these results in relation to in-person social communication will need to be explored. Given Engert et al.'s (Engert et al., 2014) findings that suggest stress contagion is stronger via one-way mirror as compared to video, our findings may actually be amplified should they be tested in an in-person setting. Finally, while our results do demonstrate physiological changes in response to stress of others, I cannot draw any health implications from our specific set of data, as I relied on IBI as our biological measure, and our study was designed to measure acute changes, not long-lasting ones. IBI is directly influenced by both the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). An important next step in this area of research is to examine the dual influence of the SNS and PNS in relation to stress contagion, and to determine which system is primarily responsible for changes in IBI in response to stressed others. Low heart rate variability (a measure of PNS activity) has been shown to be a marker of all-cause mortality, thus I believe it especially important to examine whether the PNS plays a role in stress contagion, and if it does, whether these changes in PNS can be long-lasting. Future work should measure SNS and PNS concurrently, and consider employing a longitudinal design to determine whether these effects can be persistent in an individual if one is chronically exposed to stressed others.

These data add to the existing literature of emotional contagion research, and bolster the idea that stress can be contagious on a psychophysiological level, albeit in a more complex way than previously recognized. These particular findings are of importance as they demonstrate that individuals can detect stress in others, even in the absence of overt context-dependent stress cues (i.e., stressful topic of speech), and have cardiac responses that are related to those of the speaker. Future research will be necessary to further investigate the mechanisms behind these effects, for example, which modalities are most important in the transmission of stress from one person to another.

Overall these results add to our mechanistic understanding of stress contagion. Reacting to another's affective state is an important factor in forging and maintaining social connections, and future work in this direction may help us gain insights into its psychophysiological underpinnings. First, reacting to another's affective state is an important factor in forging and maintaining social connections (Cacioppo & Hawkley, 2009), and also because second-hand stress may have similar health consequences to first-hand stress (Cacioppo, 1994). Furthermore, studies on the autonomic nervous system's role in stress contagion will be important in determining whether second-hand stress may have similar health consequences to first-hand stress. Understanding others is the basis for our lives as social beings, and emotional contagion research helps to inform our knowledge of the transmission and reception of affective states between two individuals.

APPENDIX A: FIGURES FOR CHAPTER 2

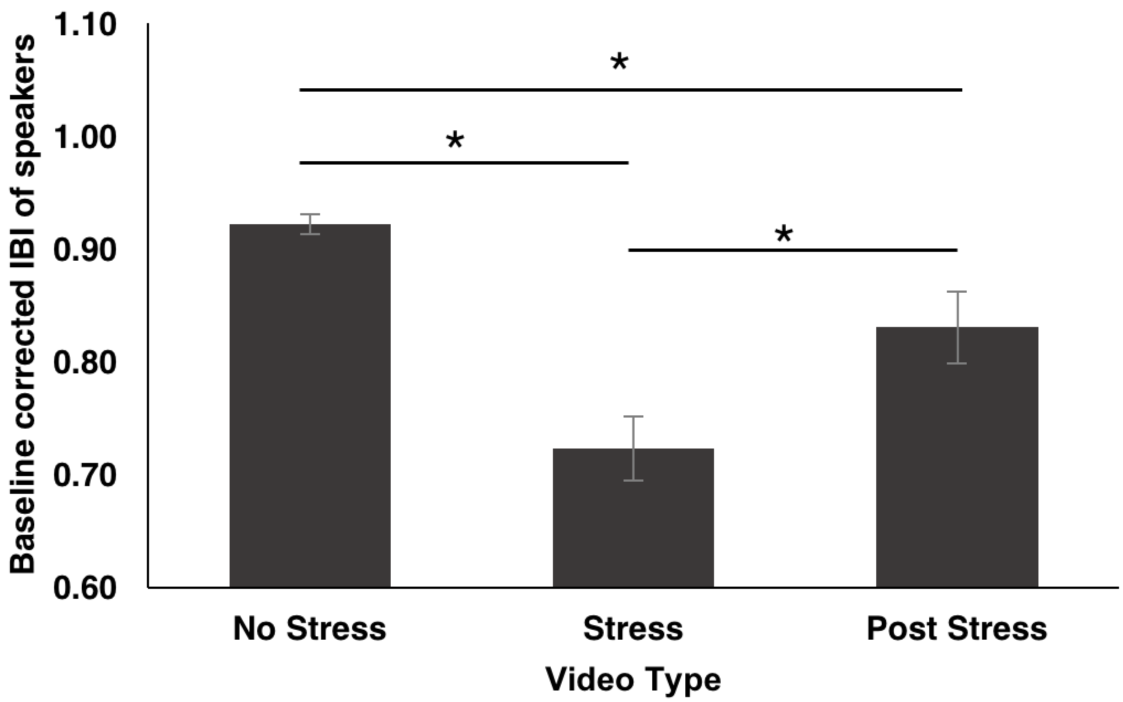

Figure 1. 3 Mean baseline corrected IBI of speakers in the "No Stress", "Stress" and "Post Stress" conditions.

Error bars represent standard error.
* = statistically significant at $p < 0.05$

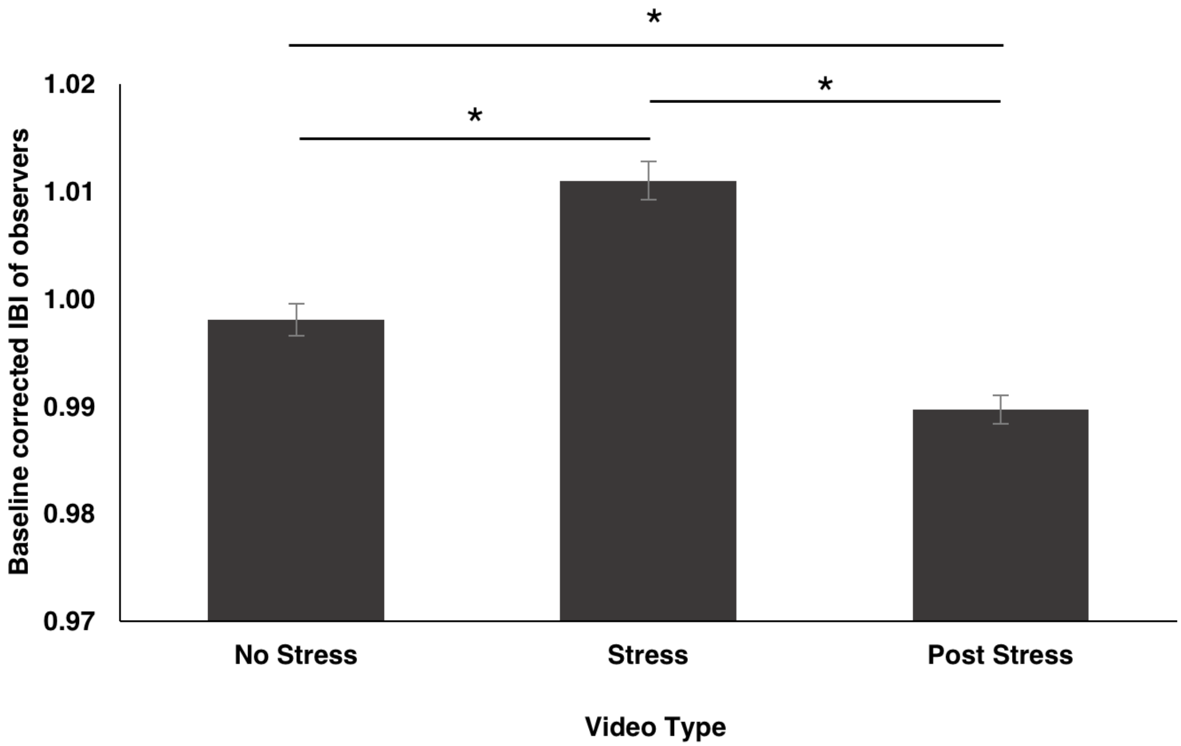

Figure 1. 4 Mean baseline corrected IBI of observers while watching “No Stress”, “Stress” and “Post Stress” videos.

Error bars represent standard error for repeated measures.
* = statistically significant at $p < 0.05$

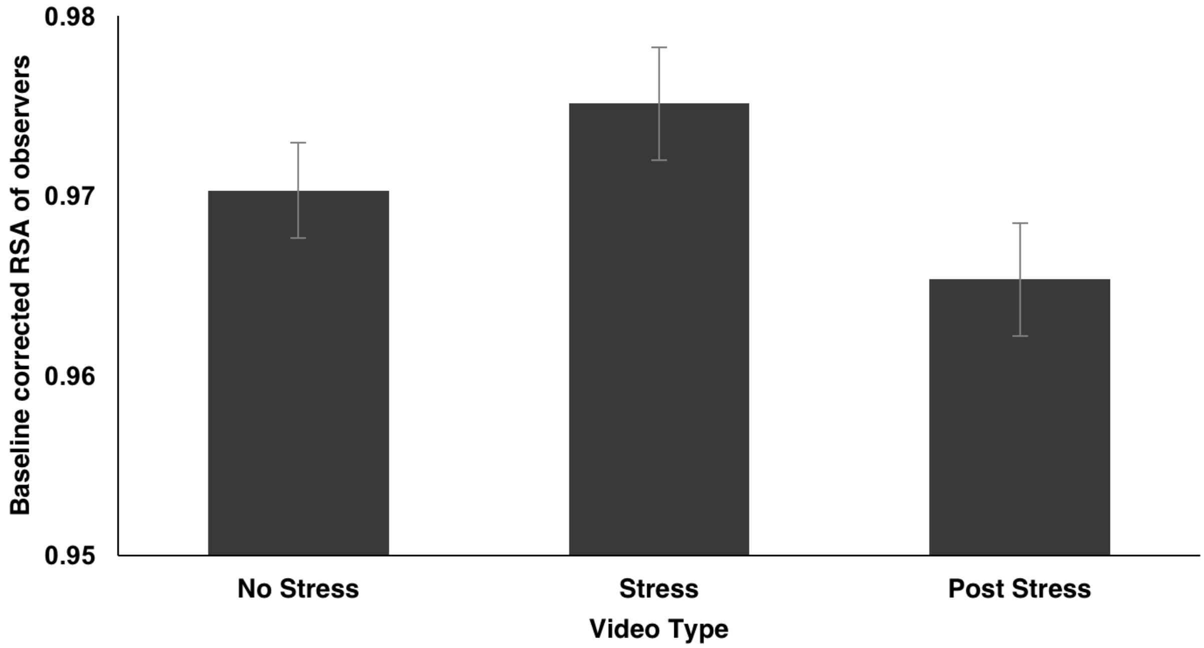

Figure 1. 5 Mean baseline corrected RSA of speakers in the “No Stress”, “Stress” and “Post Stress” conditions.

Error bars represent standard error for repeated measures.

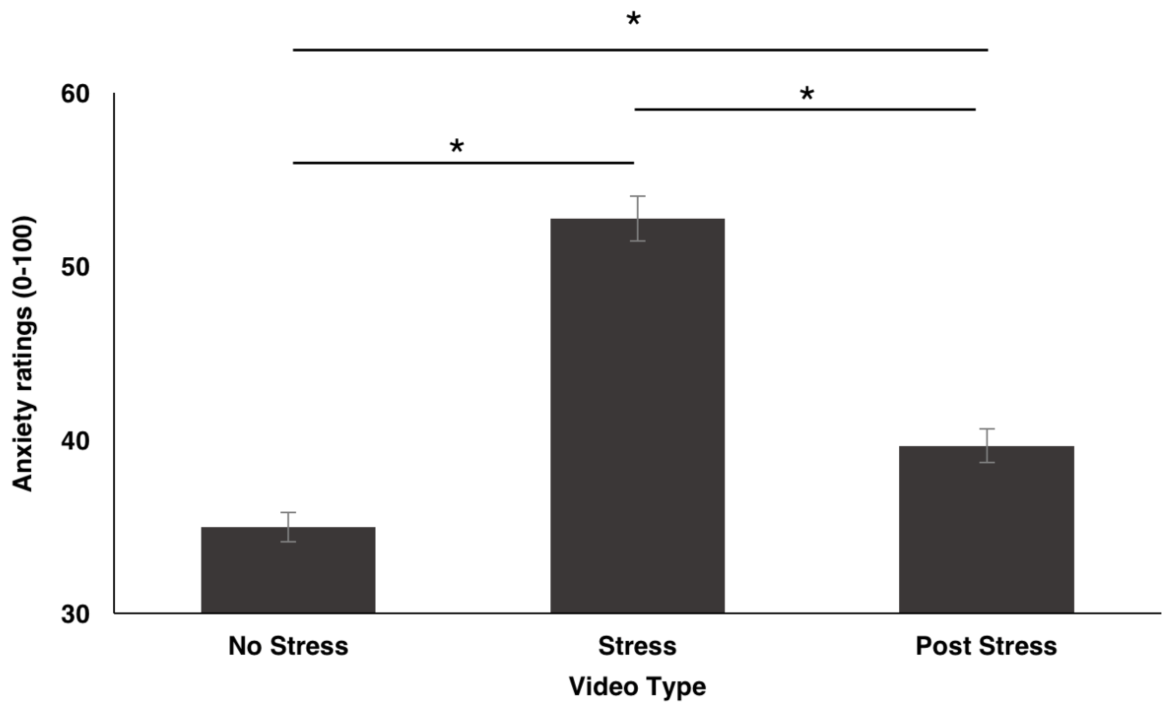

Figure 1. 6 Observers' mean anxiety ratings of speakers in the "No Stress", "Stress" and "Post Stress" conditions.

Error bars represent standard error for repeated measures.
* = statistically significant at $p < 0.05$

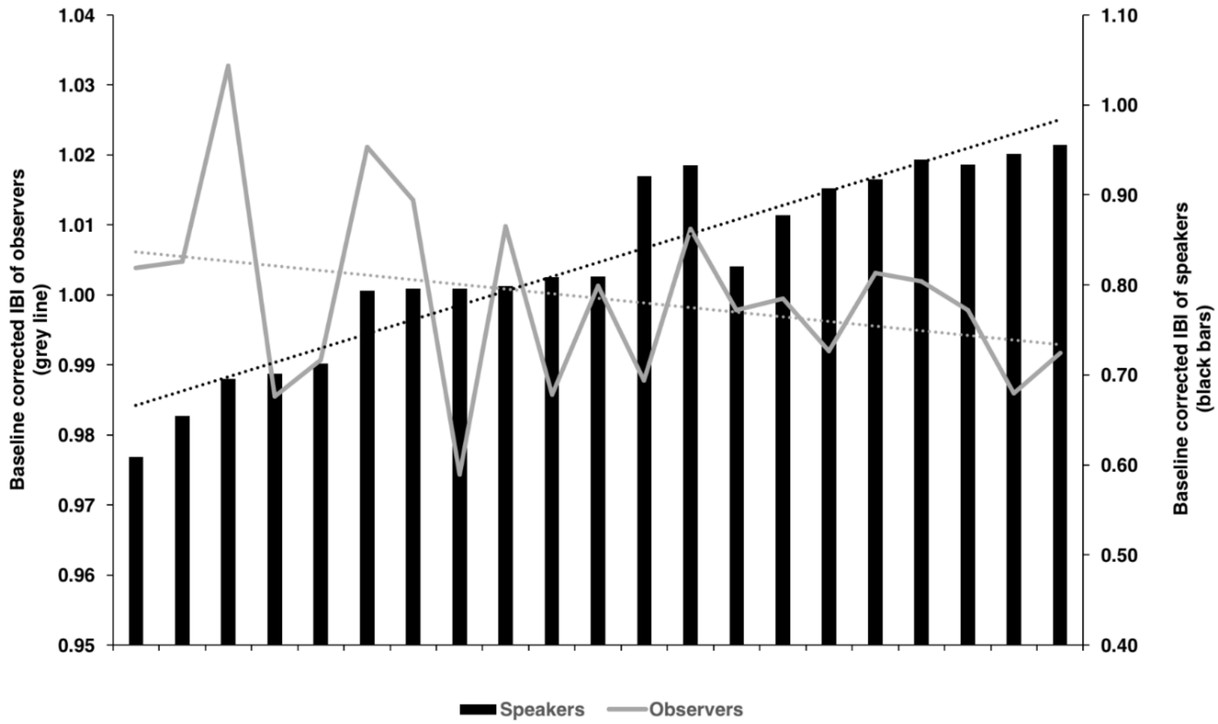

Figure 1. 7 Visual aid illustrating the relationship between baseline corrected IBI of both speakers and observers for all 21 videos.

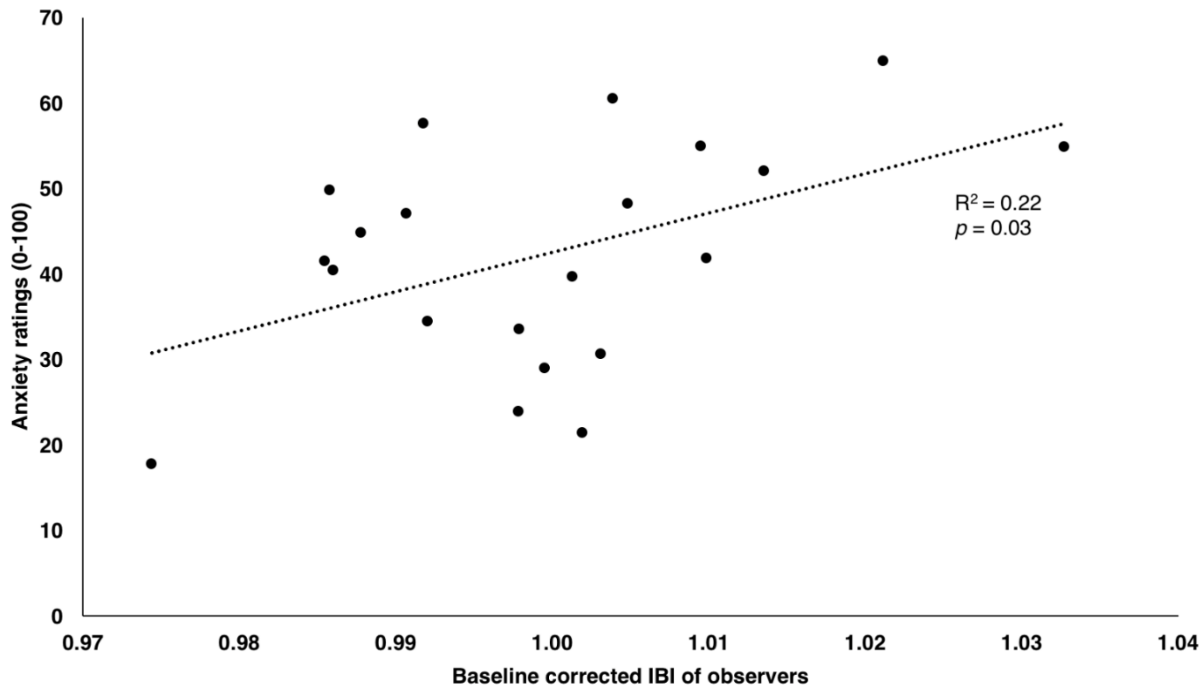

Figure 1. 8 Correlation between the average anxiety rating for each video and the average baseline corrected IBI of observers while watching each video

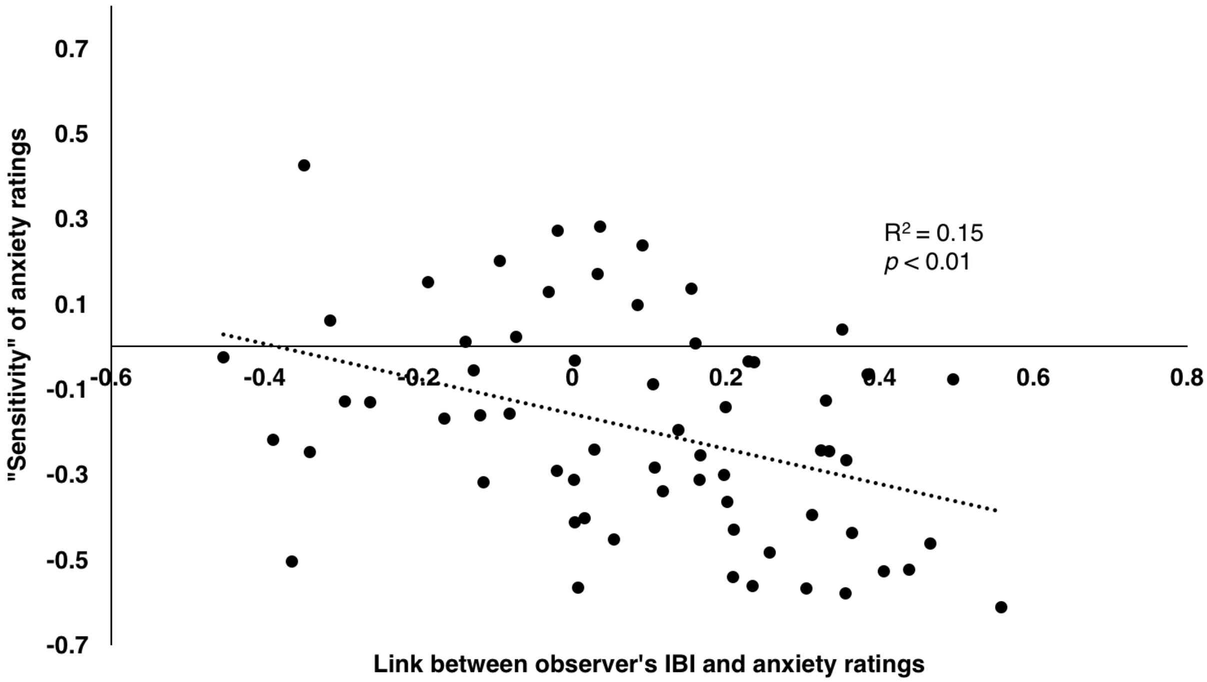

Figure 1. 9 Correlation of the link between observers' anxiety ratings of videos and their own IBI while watching videos, and the "sensitivity" of their anxiety ratings
The maximum "sensitivity" score is indexed by -1.00, as lower IBI's represent higher levels of stress.

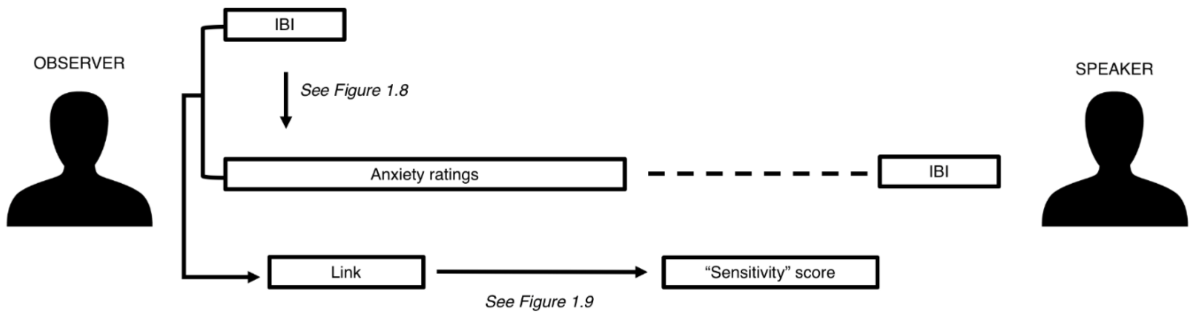

Figure 1. 10 Visual representation of the relationship between IBI of the speakers, observers and anxiety ratings made by observers about speakers.

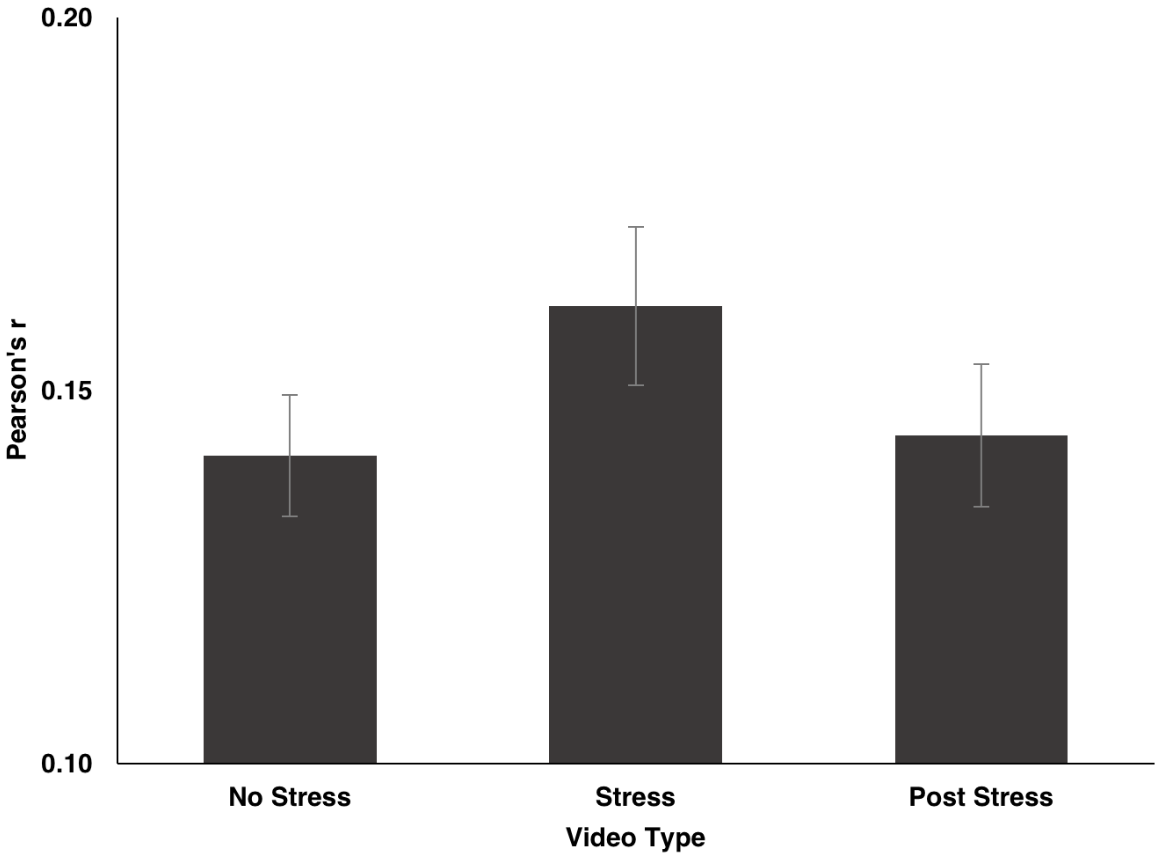

Figure 1. 11 Mean maximum time-lagged correlation between IBI of speakers and observers Error bars represent standard error for repeated measures.

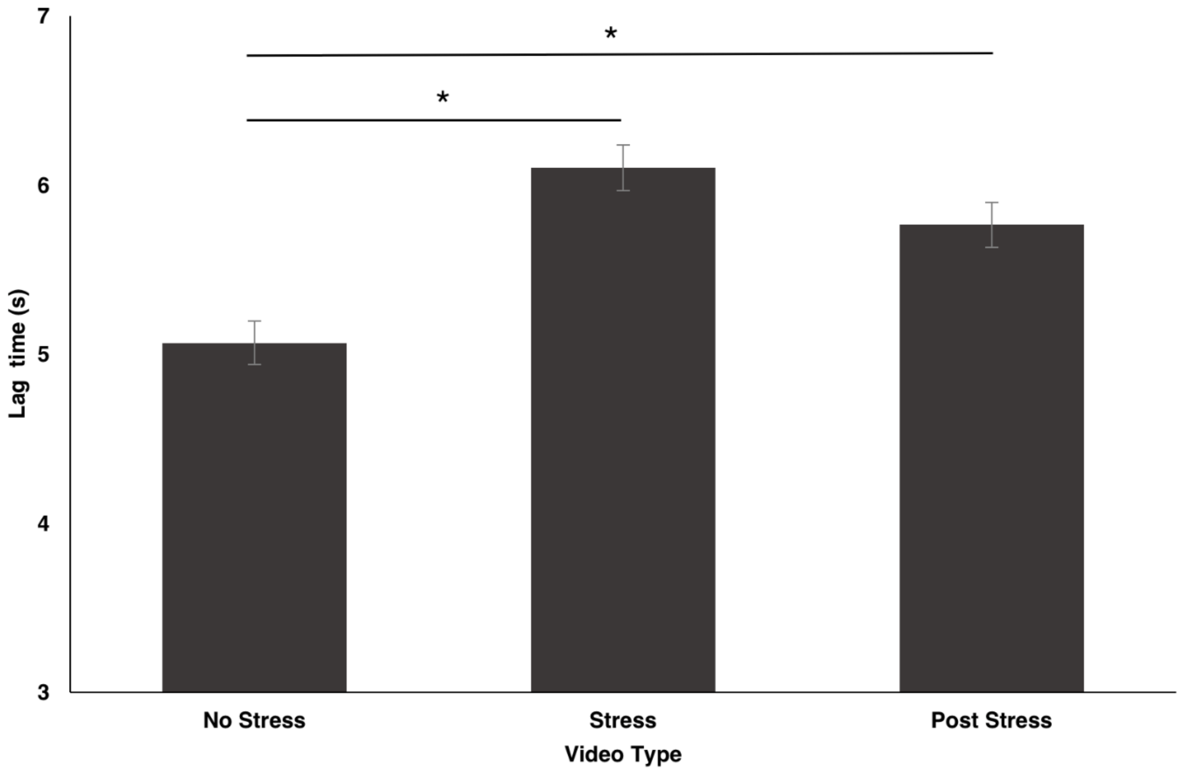

Figure 1. 12 Mean lag (in seconds) to reach maximum correlation between IBI of speakers and observers.

Error bars represent standard error for repeated measures.

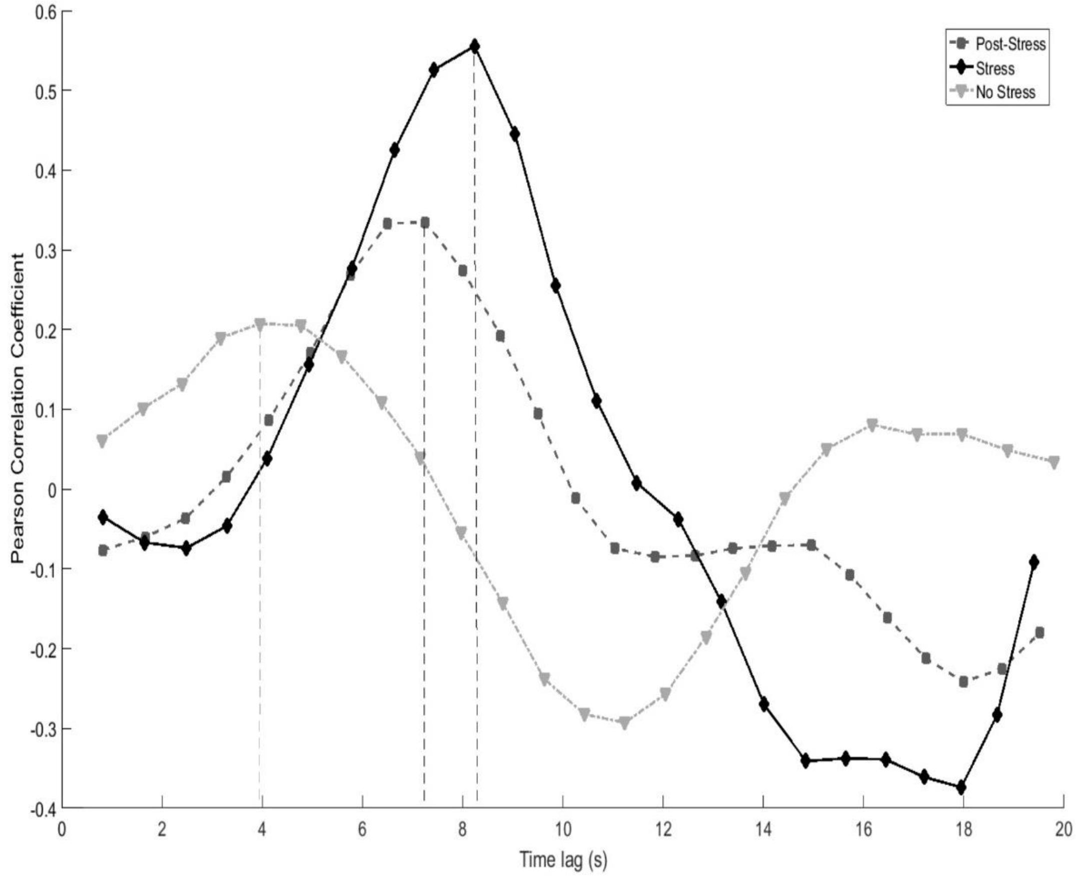

Figure 1. 13 Visual representation of time lag analyses.

These data represents one subject. Each line represents the correlation of observer's IBI with speaker's IBI, for each video type. As the time lag is increase from zero, one is able to determine the maximum correlation achieved.

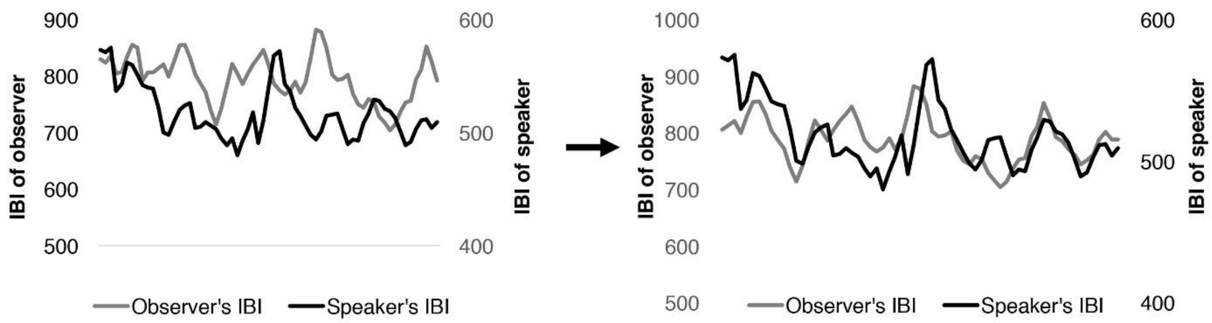

Figure 1. 14 Visual representation of IBI data of observer from Fig. 1.13 watching a “Stress” video

The graph on the left shows how IBI of speaker and observer are related when no time lag is implemented. On the left, we see how IBI of speaker and observer are related when a time lag of approximately 8 seconds is applied. A secondary axis was created to help visualize differences in IBI, as the speaker was robustly stressed and as a result had a lower IBI as compared to the observer

CHAPTER 3: ALTRUISTIC PUNISHMENT FOLLOWING OSBSERVED SOCIAL REJECTION

INTRODUCTION

Experiencing an aversive event can be instructive in some contexts. It can help us to adapt and cope with similar situations in the future (Bingel, Schoell, Herken, & May, 2007; Luhmann & Eid, 2009). Importantly, these experiences can also provide insight into the emotional state of others who experience similar events (Barnett, Tetreault, & Masbad, 1987; Batson et al., 1996; Eklund, Andersson-Straberg, & Hansen, 2009; Hodges, Kiel, Kramer, Veach, & Villanueva, 2010; Vollhardt, 2009). Bystanders to such situations that involve a clear offender of social justice have the option to intervene. For example, if observing someone else being verbally abused, the suite of behavioral responses one may choose include consoling the victim, or chastising the perpetrator. An individual's ultimate response is dependent upon a multitude of factors, including one's empathy for the victim, which may be elevated in individuals with high dispositional empathy, or individuals who have experienced similar events in the past (Barnett et al., 1987; Batson et al., 1996; Eklund et al., 2009; Hodges et al., 2010). While choosing to console the victim can immediately benefit him or her, effectively punishing the perpetrator can have longer-lasting effects (Leliveld, Dijk, & Beest, 2012). Punishing wrongdoers is a high-risk behavior for a bystander, however it can act as a salient deterrent, and potentially protect the victim and prospective victims from future unjust treatment (Carlsmith, Darley, & Robinson, 2002; Fehr & Gächter, 2002).

Punishment of a third-party for unfair treatment of an individual or group has been generally referred to as altruistic punishment (Fehr & Gächter, 2002). Evolutionarily, altruistic punishment has been posited to be a driving force for successful cooperative group living

(Fowler, 2005). By living in social groups humans were better protected from predators, and were able to divvy up the labor for energetically demanding tasks such as hunting and foraging, which resulted in more food to be distributed and shared amongst group members (Alexander, 1974). However, cooperating with group members would be disadvantageous if defectors began to take advantage of communal benefits without contributing (Fowler, 2005). Therefore, it can be seen as adaptive to punish free-riders. It has been experimentally demonstrated that in groups where punishment is permitted, individuals will punish defectors, which then leads to an overall increase in group cooperation (Fehr & Gächter, 2000, 2002). While there have been many studies that demonstrate the partial existence of altruistic punishment in humans (e.g. Strobel, Zimmermann, Reuter, & Windmann, 2011; Crockett, Clark, Lieberman, Tabibnia, & Robbins, 2010; Masui, Iriguchi, Nomura, & Ura, 2011; Shinada, Yamagishi, & Ohmura, 2004; Vinkers et al., 2013; Weng, Fox, Hessenthaler, Stodola, & Davidson, 2015), they have almost exclusively utilized economic games to create situations of unfairness. This methodology appropriately models unfair resource distribution, and may be somewhat similar to some types of real-life social transactions but it differs in nature from injustices that are more personally targeted. There has been little to no research conducted on altruistic punishment outside of the economic domain. Human society operates on cooperation, however much of it being independent from strict resource sharing. Successful group living and cooperation also relies on group cohesion. Group cohesion starts to break down when group members will treat others unfairly, whether it be by insulting another or injuring another. Take for example, waiting in line at a bank. We cooperate by respecting other line members and taking our rightful place at the end of the line. If an individual were to publically insult someone in line and cut in front of them, cooperation could be reestablished by someone willing to speak up and reprimand this norm breaker. While we can anecdotally surmise that there are individuals who would be willing to defend the person being insulted, this kind of altruistic punishment has rarely been studied. In these situations, altruistic punishment involves taking action, instead of passively penalizing by withholding resources. Furthermore, it involves punishing someone who is willing to psychologically or physically harm others, as opposed to someone who is not willing to fairly share their resources. Such perpetrators are likely to be more dangerous than those who are merely greedy. To what degree is altruistic punishment also seen in response to these more personal social injustices? I am particularly interested in whether individuals will punish others after viewing an instance of undeserved social rejection. Being rejected is an aversive experience, as it potentially destabilizes one’s social standing, and having a third-party intervene and punish on one’s behalf could prove a valuable deterrent. This study aims to investigate whether altruistic punishment occurs in response to viewing another individual be rejected, and which traits may predispose one to engage in this behavior.

One of the most psychologically aversive experiences is feeling personally rejected by an individual or a group (Baumeister & Leary, 1995; Cacioppo et al., 2006). Humans form attachments to others from early infancy and throughout their lifespan; feeling socially connected to others is an essential part of physical and psychological well-being (Cacioppo et al., 2000). Being rejected signals a threat to group membership, something that humans, like other non-human social mammals, are especially sensitive to as belonging to a group is necessary for all parts of life, and ultimately, to survival. After being rejected, individuals report depressed moods, sadness, reductions in self-esteem, and hurt feelings (Blackhart, Eckel, & Tice, 2007; Buckley, Winkel, & Leary, 2004). Rejection also has been shown to elicit an acute increase in inflammatory activity (Slavich, Way, Eisenberger, & Taylor, 2010) and sensitivity to pain

(Eisenberger, Jarcho, Lieberman, & Naliboff, 2006). Far from being an uncommon event, adults report feeling ostracized on a regular basis (Nezlek, Wesselmann, Wheeler, & Williams, 2012). Given the detrimental effects of being rejected, it is important to understand how third-parties react when observing someone else being unfairly rejected.

Bystanders of social rejection have the ability to intervene and improve the victim's outcome. Punishing the perpetrator in such situations can potentially end the rejection episode, reassure the victim that others are willing to help, and deter the perpetrator from doing so again. Having a third-party intervene on one's behalf may also be perceived as receiving acceptance from another, which has been shown to buffer against negative affect from being rejected (Dewall, Twenge, Bushman, Im, & Williams, 2010). However, choosing to punish the offender comes at a cost. Risks can range from decreasing one's social standing to incurring personal injury. It remains unclear what psychological and physiological factors may predispose an individual to intervene, despite the inherent costs. Previous research has demonstrated that shared past experiences may make one more empathetic to others, thus victims of repeated rejection in the past (i.e. bullying victims) may be most likely to intervene in such situations. Another important factor that may affect one's actions when observing rejection is one's dispositional empathy, or the lack thereof that is seen in individuals high in psychopathy. While empathy may make one more motivated to engage in prosocial behavior, a recent study revealed that individuals with low levels of empathy were most likely to altruistically punish (Leliveld et al., 2012). Furthermore, individuals with higher levels of psychopathy have also been shown to exhibit increased altruistic punishment behavior (Masui et al., 2011). Finally, physiological indices might play a role in one's final behavioral response. Resting parasympathetic nervous system (PNS) activity is related to one's flexibly in response to environmental changes and emotional control (Norman et al., 2014). As such, resting PNS activity may be important in how one reacts to viewing someone else be rejected. Furthermore, emotional reactions to observing rejection in another, as measured by changes in autonomic nervous system (ANS) activity may affect one's motivations to intervene. While not an ANS study, an fMRI study by Masten et al. (2011) found that activation of the insula in response to observing exclusion resulting in participants writing more prosocial letters to their rejected peers. Just as neural activity in response to viewing rejection may predict later behavior, ANS might also provide similar insight, given how implicated it is in emotional responding.

The present work investigates whether adults will engage in altruistic punishment after observing an instance of social rejection. In contrast to prior research that has investigated altruistic punishment, we did not have participants witness an unfair economic decision, but instead, had them watch a realistic instance of someone being bullied. Furthermore, in addition to replicating past research by allowing participants to monetarily punish, we also gave participants the opportunity to administer sound blasts, which models more active forms of punishment that a bystander might engage in. For the purposes of this paper, we use the term "bully" to refer to someone who uses their power to reject and unfairly criticize others, and the term "victim" to refer to the individual being rejected. In order to create a realistic bullying episode, we led participants to believe that they were interacting with two other participants in other experimental rooms. After being introduced via video, they were told that they (Participant C) and Participant B would be evaluating Participant A's likeability as part of a friendship study, and that Participant A would get to read both of their evaluations. Participants were also able to read Participant B's evaluation of Participant A. In the control condition, Participant B's evaluation of Participant A was positive, and in the experimental condition, the evaluation was unjustly negative. In this scenario, Participant B is given the power to judge Participant A, and they use this power to denigrate them, which, for the purposes of this experiment, we consider bullying. Following this manipulation, participants completed a task where they could administer sound blasts to Participants A and B, and then completed a two-recipient dictator game (as described in Engel, 2011). Both of these tasks were used to measure punishment behavior. The goals of this study were fivefold: (i) to determine whether adults would altruistically punish a bully who rejected a stranger, (ii) to determine whether a history of being bullied would increase one's likelihood of punishing a bully (iii) to assess whether and how empathy and psychopathy were related to subsequent punishment behavior, (iv) to determine how resting PNS activity is related to altruistic punishment and (v) to determine how ANS activity in response to viewing rejection influences later behavior.

METHODS

Participants Eighty-three healthy volunteers between the ages of 18 and 25 (M = 19.90, SD = 1.59, 49 female, 39 Caucasian) took part in the study. Participants were instructed to refrain from consuming caffeine or participating in strenuous activity for two hours prior to participation. All participants provided written informed consent and were paid or given course credit for their participation.

Procedure The study was approved by the University of Chicago Institutional Review Board. Participants first answered a survey of general demographic information, and completed a set of psychological questionnaires including the Psychopathy Personality Inventory (PPI; Benning, Patrick, Hicks, Blonigen, & Krueger, 2003), and the Questionnaire of Cognitive and Affective Empathy (QCAE; Reniers, Corcoran, Drake, Shryane, & Völlm, 2011). Once completed, participant speakers were fitted with surface electrodes for the measurement of the electrocardiogram. Participant speakers were given a standard grey shirt to wear and instructed to sit in a chair that was in front of a wall draped with a white sheet. They faced a 39" LED TV with a webcam installed on top of it. The experimenter informed participants that the aim of the present study was to determine how people perceive and judge others, and how these perceptions and judgments inform their friendship making decisions. Participants were told that in order to test this, they would be partaking in the experiment with two other individuals who are located in two other nearby testing rooms (these participants were fictitious), and that in order to "meet" one another, they would all be videotaped, and then watch each other's video tapes. Participants were provided with a prompt for their video; they were instructed to talk for two minutes about their morning routine. This prompt was chosen due to its unemotional nature. Once videos were recorded, the experimenter pretended to save the video file onto a USB key and then left the room, telling the participant they would go deliver their video and collect the videos of the two other participants. After approximately a minute, the experimenter returned and played two pre-recorded one-minute long videos (on the topic of morning routines), under the ruse that they were the participants in the other room. Four videos (one male pair and one female pair) were selected from a larger stimulus set of videos of individuals being recorded talking about their morning routines. All participants viewed recordings of same-sex individuals, and were told that one individual is "Participant A" and the other is "Participant B". The order of the videos, as well as which video was assigned to be A or B was counterbalanced across trials. Participants were then told that "Participant A" was randomly assigned to be judged, and that they, along with "Participant B", were to act as judges. Participants were then given two copies of a questionnaire I created entitled the "Perceived Likeability Questionnaire" (PLQ) which was composed of 12 multiple-choice questions designed to allow participants to answer questions about another individual's intelligence, likeability, attractiveness, etc. (see Supplementary Materials). Participants were told to fill out two identical copies of the PLQ about Participant A; one to be delivered to Participant A so they could see ratings about themselves, and the other to Participant B, so they could compare responses. Once participants completed the two PLQs and placed them in two manila folders, the experimenter collected their questionnaires and left the room to ostensibly deliver them and retrieve Participant B's PLQ about Participant A. While outside the room, the experimenter retrieved a pre-completed PLQ (Participant B's), which served as the experimental manipulation of this study. A score of 100% on the PLQ would indicate all responses chosen were the most positive. The pre-completed PLQs were either 90% positive, (representing the control condition) or 27% positive (the experimental condition). Within condition, the responses to all PLQ questions were identical. Prior to the start of the study, all pre-completed PLQs were inserted into individual manila folders and shuffled. Thus, when the experimenter retrieved the manila folder, they did not know the contents, which ensured a double-blind procedure. The experimenter then returned to the testing room, gave the participant the PLQ in the manila folder, and instructed them to read Participant B's judgment of Participant A.

Once participants indicated that they were finished reading, they were informed about the second phase of the experiment, which involved "playing games" with Participants A and B. Their first task was a sound blast paradigm programmed in E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA). Participants were told that they would be playing a social cognition game, and they were assigned to be the "distributor" while Participants A and B were assigned to be players. Participants were randomly assigned to play with either Participant A or B first, and were led to believe that they were seeing the player's screen mirrored on the screen in front of them. The screen displayed a series of twelve neutral faces, followed by a series of three faces, and participants believed that the player had to indicate whether all three faces were a part of the previous twelve. After each trial participants were able to see whether the player was correct or incorrect. When they were incorrect, a volume bar appeared, and participants were able to adjust the volume of a sound blast that the player would then receive through headphones. At the onset of the game, participants were made to hear what the sound blast sounded like when set to the middle of the bar. Participants played 10 trials with each player. Five of these trials were programmed to be incorrect responses, with the order of incorrect responses being fixed. Participants then played a two-recipient dictator game where they were able to distribute $10 USD amongst themselves and Participants A and B in any way of their choosing. See Figure 2.1 for a timeline of the procedure.

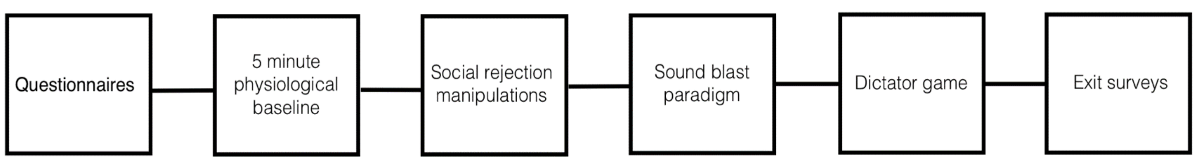

Figure 2. 1 Schematic of procedure for Study 2

Physiological measures A standard lead II configuration was used for obtaining the electrocardiogram (ECG) on both speakers and observers. ECG data were used to assess inter-beat interval (time in ms between heart beats) and high frequency heart rate variability (HF-HRV) as indexed by respiratory sinus arrhythmia (RSA). HF-HRV is a rhythmic fluctuation of heart rate in the respiratory frequency band, and has been demonstrated to be a fairly pure index of parasympathetic nervous system activity. RSA was derived from the ECG using spectral analysis that isolated the respiratory band (0.12 – 0.42 Hz) by filtering out both low- and mid-frequency heart rate variability. The inter-beat interval series was time sampled at 4 Hz (with interpolation) to yield an equal interval time series. The time series was detrended (second-order polynomial), end tapered and submitted to a fast Fourier transform. RSA magnitude was indexed by the natural log of the heart period variance within the respiratory frequency band (in ms^2). Data were collected using a BioNex two-slot mainframe (Mindware Technology, Gahanna, OH) which was connected to a personal computer. The sampling rate of the electrocardiogram (ECG) signal was 1000 Hz.

IBI and RSA were recorded during a five-minute baseline, during video recording, video watching, filling out the PLQ, reading the PLQ, the sound blast paradigm and the dictator game. For the purposes of this study, I analyzed the data during baseline and reading the PLQ. Analysis of the ECG signal was performed using Mindware Technology's HRV software, Version 3.10. Visual inspection and manual editing of the data was completed to ensure proper removal of all artifacts and ectopic beats (Bernston et al., 1997). RSA and IBI were score minute by minute.

After the two games, participants completed a closing survey on a laptop. The closing survey included questions about their past history of being bullied (see Supplementary Materials), how sorry they felt for Participant A, how upset they felt with Participant B and how believable the felt the study to be. Finally, participants were debriefed and compensated the money they earned from the dictator game and either $10 or 1 course credit for their participation.

Statistical Analysis All data was analyzed using IBM SPSS Version 24 (SPSS Inc., Chicago, IL). Sound blast volumes were on a scale of 0 to 100. Sound blasts volumes were averaged over the five error trials. Outlier checks were conducted with all data. Data was excluded if it was more or less than three standard deviations from the mean.

RESULTS

For simplicity, Participant A will be referred to as the victim, and Participant B will be referred to as the bully, in both control and experimental conditions.

A two-way mixed measures ANOVA revealed a significant interaction effect between experimental condition and player (bully/victim) in volume of sound blasts administered, $F(1,78) = 9.94$, $p = 0.002$ (see Figure 2.2). Post hoc paired t-tests revealed that participants administered significantly louder sound blasts to the bully, as compared to the victim, in the experimental condition $t(39) = 3.20$, $p = 0.002$ ($M\text{victim}_{\text{experimental}} = 18.27$, $M\text{bully}_{\text{experimental}} = 24.41$). A post hoc t-test also revealed significantly louder volumes were administered to the bully in the experimental condition as compared to the control condition $t(78) = -2.31$, $p = 0.024$ ($M\text{bully}_{\text{control}} = 15.16$, $M\text{bully}_{\text{experimental}} = 24.41$). The difference in volumes was not significant in the control condition $t(39) = 0.30$, $p = 0.767$ ($M\text{victim}_{\text{control}} = 15.39$, $M\text{bully}_{\text{control}} = 15.16$).

A two-way mixed measures ANOVA revealed a significant interaction effect between experimental condition and experimental player (bully/victim) in amount of money given away in the dictator game, $F(1,81) = 8.09$, $p = 0.006$ (see Figure 2.3). Post hoc paired t-tests revealed that participants distributed significantly less money to the bully compared to the victim in the experimental condition, $t(42) = 3.09$, $p = 0.004$ ($M\text{victim}_{\text{experimental}} = \$3.04$, $M\text{bully}_{\text{experimental}} = \$2.27$). A post hoc t-test also revealed a trend of less money given to the bully in the experimental condition as compared to the control condition $t(81) = 1.91$, $p = 0.06$ ($M\text{bully}_{\text{control}} = \$2.88$, $M\text{bully}_{\text{experimental}} = \$2.27$). The difference in volumes was not significant in the control condition, $t(39) = 0.57$, $p = 0.574$ ($M\text{victim} = \$2.91$, $M\text{bully} = \$2.88$).

There was a significant correlation between the difference in volume administered to bully and victim, and the difference in money given to bully and victim in in the experimental condition, $r(40) = -0.66$, $p < 0.01$, while the correlation was not significant in the control group, $r(40) = -0.04$, $p = 0.79$ (see Figure 2.4).

Physiological changes in response to the PLQ were calculated by scoring 20 seconds of data (the minimum amount of time each participant spent reading the PLQ) and baseline correcting the data by dividing it by the average of the last 20 seconds of each of the five minutes of the resting baseline. Change in IBI, $F(1,79) = 1.12$, $p = 0.291$, and RSA, $F(1,79) = 0.39$, $p = 0.534$, did not significantly differ by condition. While the mean physiological change did not differ by condition, the variability in the change significantly differed by condition for both IBI (Levene's test: $F(1,79) = 4.04$, $p = 0.048$), and RSA (Levene's test: $F(1,79) = 5.71$, $p = 0.019$). Variability in IBI was greater when reading the PLQ during the experimental condition (SD = 0.11) versus the control condition (SD = 0.07). Variability in RSA was lower when reading the PLQ in the experimental condition (SD = 0.15) versus the control condition (SD = 0.20). These group-level differences in variability did not exist for baseline IBI (Levene's test: $F(1,79) = 0.64$, $p = 0.425$), or baseline RSA (Levene's test: $F(1,77) = 1.01$, $p = 0.316$).

Six three-way mixed measures ANOVAs with the dependent variables being volume to bully and victim were performed with the covariates of bullying history (categorical variable coding for responses yes/no/maybe to question "were you bullied in your past?"), empathy (total score of QCAE), psychopathy (total score of the PPI), resting state RSA, RSA change when reading the PLQ and IBI change while reading the PLQ.

Bullying history significantly interacted with volume difference and condition, $F(4,73) = 4.41$, $p = 0.003$ (see Figure 2.5). A post-hoc t-test revealed that in the experimental condition, participants who reported being bullied in the past gave significantly louder blasts to the bully, $t(29) = 2.43$, $p = 0.022$. Change in IBI in response to reading the PLQ significantly interacted with condition and volume difference, $F(4,74) = 3.78$, $p = 0.027$ (see Figure 2.6). In the experimental condition, change in IBI in response to the PLQ was significantly predictive of volume difference, $r(40) = 0.33$, $p = 0.038$. This positive relationship suggests that cardiac deceleration while reading the PLQ was related to the administration of louder sound blasts to the bully. The was no relationship between these two variables in the control condition, $r(38) = 0.01$, $p = 0.952$. There was a trending interaction with empathy, volume difference and condition, $F(2,76) = 2.75$, $p = 0.070$. A correlation with empathy and volume difference in the experimental condition revealed a negative relationship $r(40) = -0.27$, $p = 0.095$, which suggests that as empathy levels increased, volume level to the bully (as compared to the victim) decreased. No thee-way interactions were found between volume difference, condition and psychopathy, $F(2,76) = 0.23$, $p = 0.797$, resting state RSA $F(2,72) = 0.07$, $p = 0.934$, or change in RSA in response to the PLQ, $F(2,74) = 0.39$, $p = 0.679$.

A three-way mixed measures ANOVA with the dependent variables being volume administered to the bully and victim was also conducted including all six of these covariates, which were mean-centered (see Van Breukelen & Van Dijk, 2017), in the model together to ensure our results reflected any shared variance that might be explained by these variables. In this analysis the bullying history interaction remained significant, $F(4,58) = 4.53$, $p = 0.003$, and the interaction with empathy was still trending, $F(2,58) = 3.10$, $p = 0.053$. No other significant interactions emerged.

Six three-way mixed measures ANOVAs with the dependent variables being amount of money given to the bully and victim were performed with the covariates of bullying history, empathy, psychopathy, resting state RSA, RSA change when reading the PLQ and IBI change while reading the PLQ.

Bullying history significantly interacted with money difference and condition, $F(4,76) = 2.76$, $p = 0.034$ (see Figure 2.7). A post-hoc t-test revealed that in the experimental condition, participants who reported being bullied gave significantly less money to the bully, $t(17) = 3.40$, $p = 0.003$ ($M\text{victim}_{experimental}$ = \$2.05, $M\text{bully}_{experimental}$ = \$3.46). No thee-way interactions were found between money difference, condition and empathy, $F(2,79) = 0.66$, $p = 0.520$, psychopathy, $F(2,79) = 0.04$, $p = 0.960$, resting state RSA $F(2,75) = 0.04$, $p = 0.959$, change in IBI in response to the PLQ, $F(2,77) = 0.68$, $p = 0.509$ or change in RSA in response to the PLQ, $F(2,77) = 0.36$, $p = 0.698$.

A three-way mixed measures ANOVA with the dependent variables being money given to the bully and victim was also conducted including all six of these covariates, which were mean-centered (see Van Breukelen & Van Dijk, 2017), in the model together to ensure our results reflected any shared variance that might be explained by these variables. In this analysis the bullying history interaction remained significant, $F(4,61) = 2.86$, $p = 0.031$. No other significant interactions emerged.

Finally, we conducted analyses with the closing survey questions, “Did you feel sorry for the participant who was judged?” and “Did you feel upset with the other judge?” Response options were “definitely yes”, “somewhat”, “not really” and “no” which we coded numerically as ordinal variables. One-way ANOVAs revealed that participants felt more sorry for the victim in the experimental condition, $F(1, 80) = 11.22$, p = 0.001 and felt more upset with the bully in the experimental condition, $F(1, 80) = 60.36$, p < 0.001. These ratings confirm that the experimental manipulation was successful in inducing emotional reactions to social rejection in our participants.

To determine whether feeling sorry for the victim or feeling upset with the bully predicted altruistic punishment behavior, we conducted four two-way mixed measures ANOVAs with feeling sorry or feeling upset as covariates; volume difference x feeling sorry, volume difference x feeling upset, money difference feeling sorry, and money difference x feeling upset. I did not run these two covariates in the same model because these variables were highly correlated with one another ($r(82) = 0.52$, $p < 0.001$). Feeling sorry for the victim $F(3, 75) = 2.09$, $p = 0.109$ did not predict any volume differences, however feeling upset with the bully did, $F(3, 75) = 11.52$, $p < 0.001$. A paired samples post-hoc t-test revealed that, participants who reported feeling most upset with the bully gave significantly louder blasts to the bully as compared to the victim, $t(15) = 3.39$, $p = 0.004$, (*M*victim = 19.06±19.01, *M*bully= 31.94±28.63). There was no significant difference in volume blasts administered by participants who reported not feeling upset with the bully, $t(36) = 0.54$, $p = 0.593$ (*M*victim = 16.81±14.50, *M*bully= 16.85±13.35). Feeling sorry for the victim also did not predict differences in money allocation, $F(3, 78) = 1.92$, $p = 0.134$. However, feeling upset with the bully did, $F(3, 78) = 15.26$, $p < 0.001$. A paired samples post-hoc t-test revealed that, participants who reported feeling most upset with the bully gave significantly less money to the bully as compared to the victim, $t(16) = 3.61$, $p = 0.002$, (*M*victim = \$3.68±2.15, *M*bully= \$1.77±1.48). There was no significant difference in money allocation in participants who reported not feeling upset with the bully, $t(36) = 0.01$, $p = 0.994$ (*M*victim = \$3.11±1.15, *M*bully = \$3.11±1.15). The difference in money given to the victim as compared to the bully in the experimental condition is significantly correlated with participants' self-report upset ratings, $r(42) = 0.510$, $p = 0.001$. The amount of volume given to the bully as compared to the victim in the experimental condition was significantly correlated with self-report upset ratings, $r(42) = -0.485$, $p = 0.002$. Feeling sorry for the victim was not correlated with either outcome variable, $p > 0.05$.

I also scored all PLQs filled out by participants to ensure no participants independently acted as bullies. The average score was 74% positive, with a range of 47%-98% which confirmed no participants were as negative as the "bully" in the experimental condition. A one-way ANOVA revealed that there was no effect of bullying history on participants' PLQ scores, $F(2, 81) = 0.95$, $p = 0.39$. PLQ scores were also not found to be related to empathy, $r(81) = 0.13$, $p = 0.13$. PLQ score were significantly related to levels of psychopathy, $r(81) = -0.24$, p = 0.03, in that individuals with more psychopathic traits rated the victim more negatively (see Figure 2.8). Additionally, I ran two two-way mixed model ANOVAs with volume difference and money difference as dependent variables, and PLQ scores as a covariate. PLQ scores were not predictive of any later behavior on these measures, $p > 0.05$.

As a final manipulation check, participants were asked to rate how believable they thought the experiment was on a scale from 1 to 7. Median participant ratings were "3" which represented "slightly believable" and the average score was 3.77, which was between "slightly believable" and "neutral". There was no significant effect of condition on believability scores, $F(1,80) = 1.53$, $p = 0.22$.

DISCUSSION

Altruistic punishment behavior was observed in adults after viewing a stranger be socially rejected by another. This result is in line with past research on altruistic punishment in response to unequal resource distribution. However, these findings add to the literature by demonstrating that third-parties will actively punish others for breaking norms unrelated to resource allocation. These results were found between adult strangers, which suggests observing rejection can be salient enough to elicit proactive aggression towards a bully even in the absence of a relationship to the victim. This behavior was especially apparent in adults who reported having been bullied in the past, which highlights the importance past experience can have on how one reacts to another's distress. Individuals who are being unjustly rejected are amongst those who are most in need of outside intervention. In the present study, participants took the initiative to administer louder sound blasts and give less money to the bully without immediate benefit to themselves.

Most interestingly, these results demonstrate how having a history of being bullied greatly increases one's odds of punishing a bully. One likely explanation for this is that a past history of having been bullied may be associated with an increased sensitivity to rejection in others. Given the numerous negative impacts childhood bullying has on adults (Copeland et al., 2014; Sansone, Watts, & Wiederman, 2014; Takizawa, Maughan, & Arseneault, 2014; Wolke, Copeland, Angold, & Costello, 2013), these results offer a positive note to such past findings. Individuals who have had similar negative experiences to you might be the ones most likely to seek retribution on your behalf. An alternative explanation could also be that those who have been bullied are more likely to turn into bullies themselves, given research that has shown victims of bullies are less cooperative (Andreou, 2004; Perren & Alsaker, 2006). However, the data from this study are not consistent with this line of reasoning as there was no effect of bullying history on punishment behavior in the control condition, and bullying history did not predict how participants rated the victim on the PLQ. The results were clear in that bullying history did not predict general aggressiveness, only aggressiveness in line with altruistic punishment. This finding provides support for the theory of "altruism born of suffering" (Vollhardt, 2009), which posits that experiencing an aversive or traumatic event may then make one more likely to help others in similar situations.

While higher levels of dispositional empathy have been related to less altruistic punishment in past studies employing economic measures (Hu, Strang, & Weber, 2015; Leliveld et al., 2012) I postulated that the more emotional nature of rejection might have reversed this effect. However, empathy, again, was negatively related to the punishment of the bully. Empathic people are sensitive to others' emotions, and these results suggest that the sensitivity to others' emotions might stop one from engaging in behavior that could be hurtful to someone else, even if that person is a bully. Furthermore, psychopathy did not predict any altruistic punishment behavior. This could perhaps be due to individuals on the low end of the psychopathic spectrum being more empathetic (and less likely to punish) and individuals with more psychopathy not caring enough to take action. I did find a negative relationship between PLQ scores and psychopathy, suggesting that individuals with more psychopathic traits are more likely to be bullies themselves.

Physiological changes in response to reading the PLQ did not differ by condition. However, inter-individual differences in IBI and RSA did differ by condition. When reading the PLQ in the experimental condition (i.e. observing social rejection), the IBI of participants varied more widely than in the control condition. On the other hand, variation in RSA was smaller within the experimental condition. This pattern of reactivity suggests that observing social rejection did elicit physiological responses in the observers, albeit not in one unified direction. The increase in variance in IBI suggests that observers either experienced cardiac acceleration or deceleration in response to the observed rejection. Furthermore, the smaller variance observed in RSA suggests that the PNS became more rigid, and less flexible, when observing rejection. One finding of note, was that observers who experienced cardiac deceleration in response to observing the rejection, were more likely to altruistically punish the bully via sound blasts. As cardiac deceleration has been often observed in response to observing a unpleasant stimulus (Hagenaars et al., 2014; Lang et al., 1993), one likely interpretation is that individuals who found the rejection to be more aversive, were then more likely to take action against the bully. In fact, this finding is in line with past research on helping behavior that found cardiac deceleration in response to an emotional video clip predicted later helping behavior (Eisenberg et al., 1989). When considered with findings from the current study, HR deceleration appears to be a marker that may predict the likelihood of an individual engaging in a behavior that may broadly benefit the victim.

As with empathy, feeling sorry for the victim was also not related to altruistic punishment behavior. On the other hand, feeling upset with the bully was predictive of altruistic punishment behavior. This is in line with previous work by Fehr and Fischbacher (2004) which found that feelings of anger predicted punishment of a defector. Taken altogether, these findings illustrate how altruistic punishment is not strongly related to feelings of empathic concern for victims, in contrast, it is likely instigated by anger. This too is in line with the current study's bullying history findings, as it is those individuals with a history of being bullied who likely have the most ease imagining themselves being the victim, and thus become angry, and seek retribution.

While I did not specifically hypothesize whether participants would alternatively "protect" the victim, these data allow for the assessment of such behavior (i.e. delivering quieter sound blasts to the victim in the experimental condition vs. the control, and/or giving more money to the victim in the experimental condition vs. the control condition). Results did not find support for this. Participants did not deliver quieter sound blasts or give more money to the victims in the experimental condition as compared to the control. Again, these results are in line with the idea that it is anger and not empathic concern that primarily drives behaviors after viewing someone be rejected.

One limitation to the generalizability of this study, is that it was conducted with University of Chicago students, which also leads to the question of whether behavior would have differed had participants not perceived the bully and victim to be part of their “in-group”. This study also only investigated same-sex triads, so these results do not speak to how behavior might change when interacting with individuals of the opposite sex. Furthermore, there exists the possibility that the results from this study are not are specific to observing someone socially reject an individual, but instead reflect a broader response to observing negative information about another. Future work should investigate whether similar results also be elicited by other types of negative behaviors that do not directly impact another individual, such as cheating on an exam.

This study provides evidence that adults who witness someone be socially rejected will seek retributive justice. This is especially true in cases where individuals reported having been bullied in the past. This suggests that while having been bullied can result in a slew of negative outcomes later in life, it may also come with a more positive side: it may make one more likely to step in when observing someone else experience a similar rejection. Altruistic punishment is an essential part of maintaining social cohesion, as it discourages violations of social norms, and serves as a form of helping behavior. Within social groups, there are always individuals who are treated unfairly, and others who witness it. It is important for future research to continue exploring how individuals react to the observation of such unfair treatment. The more we understand how individuals react to the unfair treatment of others, the better we can identify the types of interventions that will lead to more favorable outcomes for victims.

APPENDIX B: FIGURES FOR CHAPTER 3

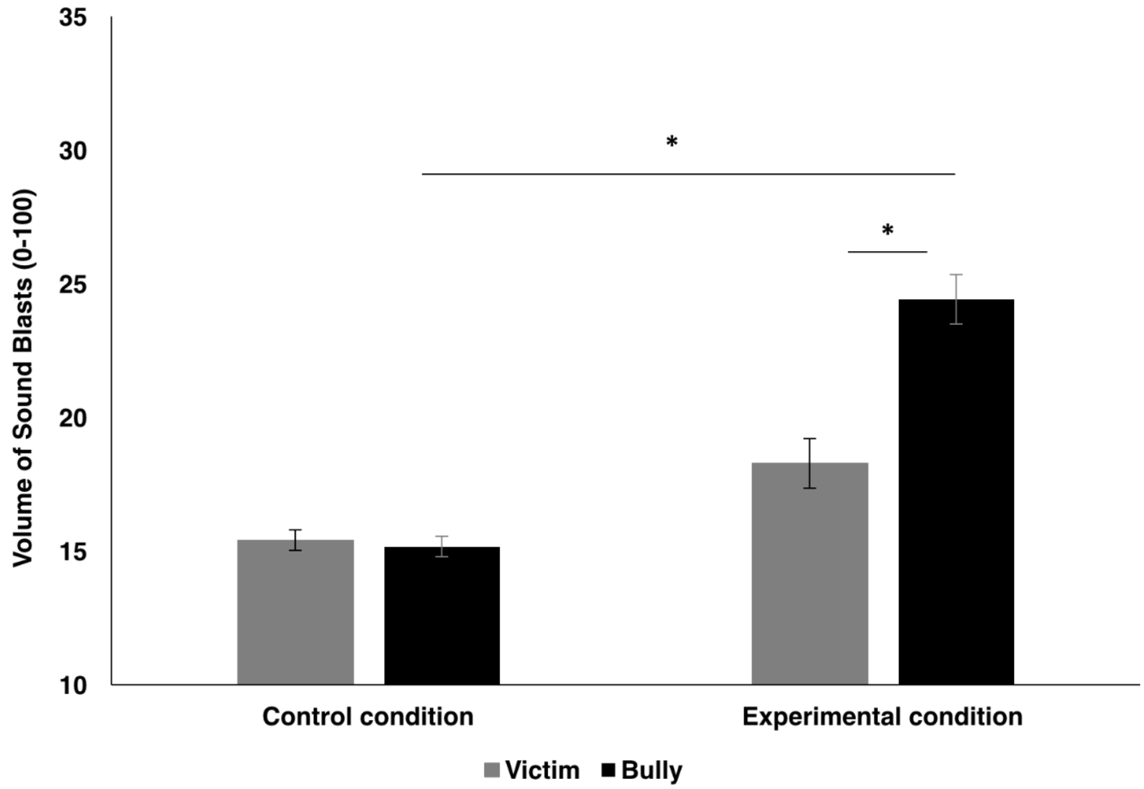

Figure 2. 2 Volume of sound blasts administered to bully and victim in control and experimental conditions.

Error bars represent standard error for repeated measures.
* = statistically significant at $p < 0.05$

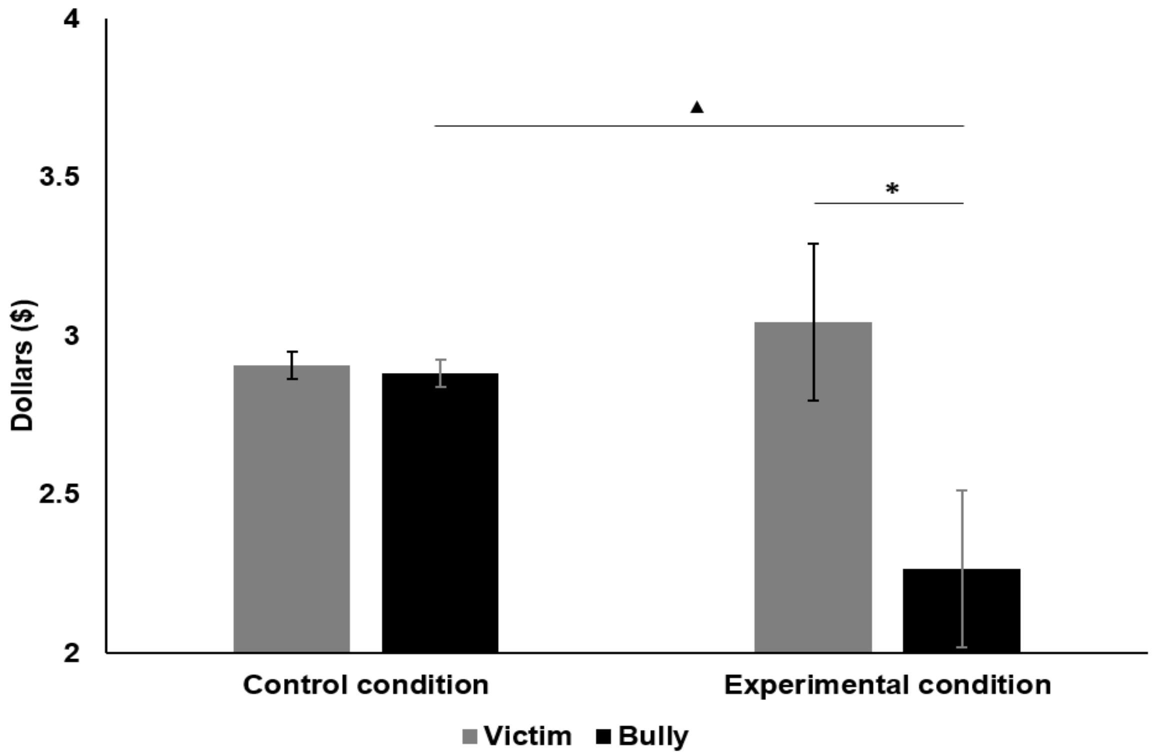

Figure 2. 3 Amount of money (out of $10) given to victim and bully in a two-person dictator game in control and experimental conditions.

Error bars represent standard error for repeated measures.
* = statistically significant at $p < 0.05$
▲ = statistically trending at $p = 0.06$

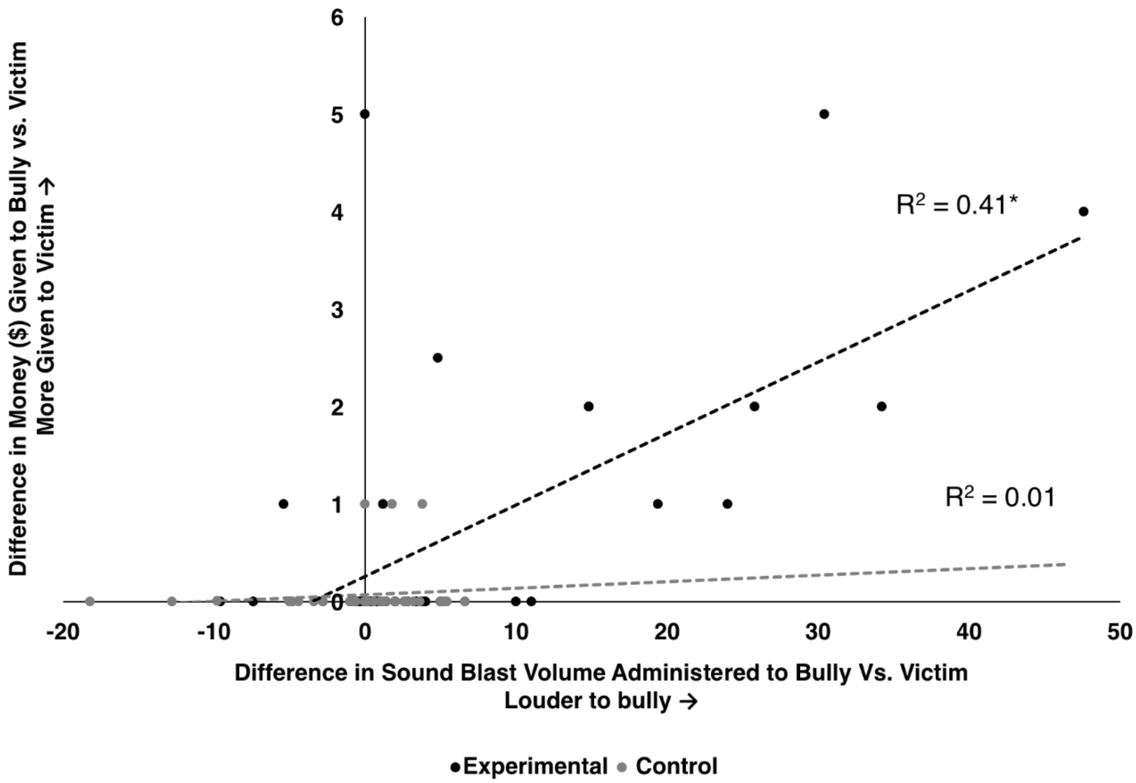

Figure 2. 4 Correlation between disparity in volume of sound blasts administered to bully and victim, and disparity in amount of money given to bully in victim, in control and experimental conditions.

* = statistically significant at $p < 0.05$

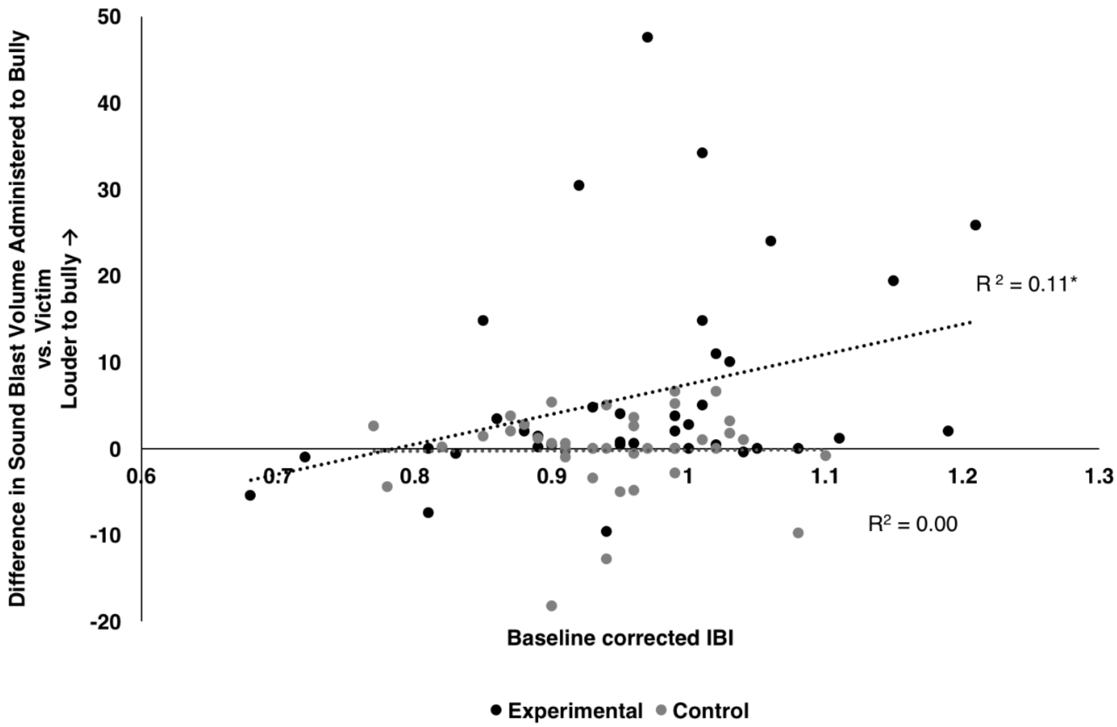

Figure 2. 5 Correlation between disparity in volume of sound blasts administered to bully and victim, and participants' change in IBI when reading the PLQ, in both the control and experimental conditions.

* = statistically significant at $p < 0.05$

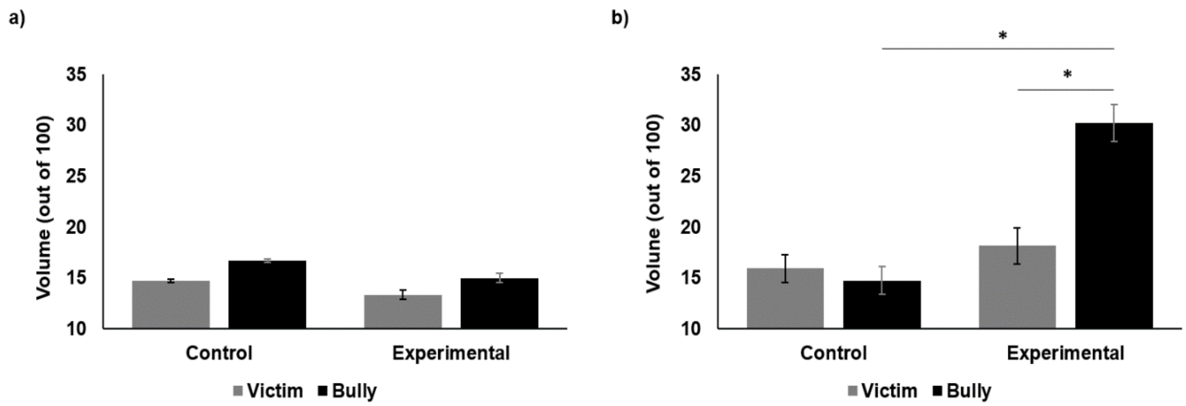

Figure 2. 6 Volume of sound blasts administered to bully and victim in control and experimental conditions in participants with and without a history of being bullied

a) Participants who reported no history of being bullied. b) Participants who reported a history of being bullied.
Error bars represent standard error for repeated measures.
* = statistically significant at $p < 0.05$

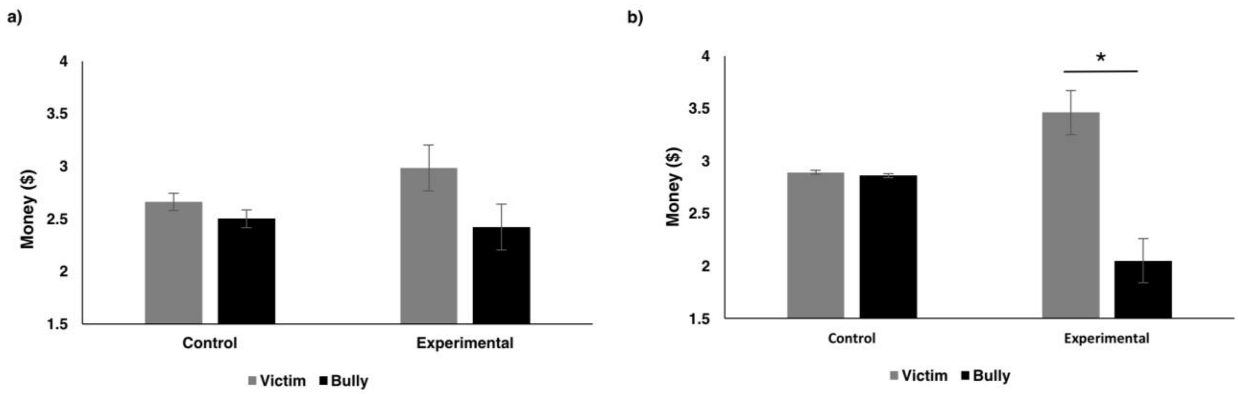

Figure 2. 7 Amount of money given to bully and victim in control and experimental conditions in participants with and without a history of being bullied

a) Participants who reported no history of being bullied. b) Participants who reported a history of being bullied.
Error bars represent standard error for repeated measures.
* = statistically significant at $p < 0.05$

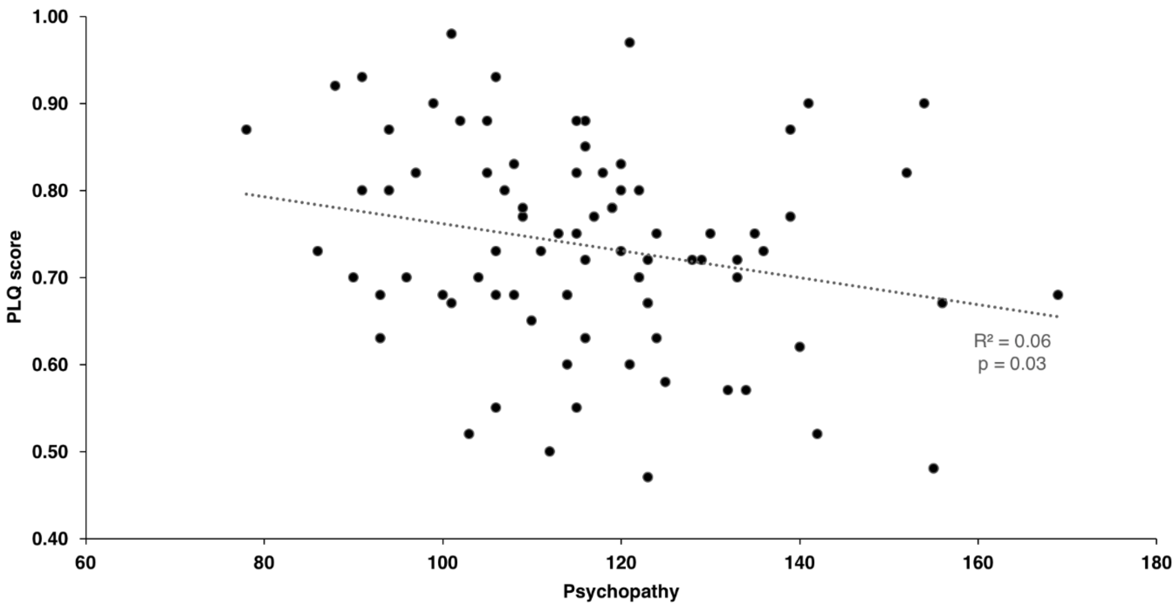

Figure 2. 8 Correlation between participant psychopathy and how they rated Participant A on the PLQ.

CHAPTER FOUR: GENERAL DISCUSSION

Emotions manifest within the individual, and as such much of the extant literature on the subject has utilized an individualist approach to the study of emotion (Rimé, 2009). This research is undoubtedly necessary, however it does not consider how emotions exist outside of a singular snapshot perspective (Butler, 2015; Rimé, 2009). While emotions arise within the organism, they are not static; they are dynamic, interpersonal, temporal systems that are constantly in flux, and affected, and shared, by those around us (Butler, 2017). As such, the study of emotion is intrinsically tied into interpersonal understanding and communication (Fischer & Manstead, 2008). Emotions can signal critical information about the environment (e.g. fear can indicate danger), but also indicate the internal state of the target, which can then motivate behavior in the observer (e.g. helping) (Vinciarelli & Bourlard, 2009). One's ability to navigate the interpersonal emotional environment is likely a strong predictor of one's success at maintaining strong supportive relationships (Kardos et al., 2017). Empathy is necessary for inferring the emotions of others (Decety & Meyer, 2008). By studying emotions in two or more individuals, researchers can study emotion with a broader scope, by investigating how emotions in one individual affect another, which has the added benefit of furthering the understanding of empathic processes.

In the present dissertation, I focused on how individuals respond when viewing distress in others. The social function of distress is posited to be a call for support, however sharing negative emotions with others also contributes to intimacy within a relationship (Fischer & Manstead, 2008), and doing so can increase relationship satisfaction (Waldinger, Schulz, Hauser, Allen, & Crowell, 2004). Whether an individual can recognize distress, react to it and choose an appropriate response to it is dependent on a number of factors that are currently not well understood. In the two studies I designed, I created paradigms that allowed me to measure psychological, physiological and behavioral responses to the distress of others, and determined how these responses were related to a number of inter-individual differences.

The broad aim of Study 1 was to determine whether stress was contagious between individuals on the level of the autonomic nervous system. I specifically focused on emotional contagion and empathic accuracy in response to stress. My main finding was that physiological changes were found in observers that differed based on the level of stress the speaker was experiencing. Most interestingly, observers responded differently to those who were recovering from stress as compared to those under no stress. The content of these videos were identical (speakers talking about a neutral topic) which highlights how observers can experience emotional contagion even without any explicit cues of stress in the target. Their anxiety ratings of the stress recovery group concurrently demonstrated that they judged those speakers as being more anxious as compared to the unstressed group. To my knowledge, this is one of the first adult human stress contagion study that used ambiguous stress stimuli (i.e. stress was not obvious by either context or direct communication). This is notable as it demonstrates how stress can also be contagious in the less intense stress recovery phase, and not only in the midst of a stressor. Which cues observers rely on to determine levels of stress in more ambiguous situations, like in stress recovery, is still an open question. Future research should explore whether the visual or auditory modality plays a stronger role in cueing distress. An unexpected finding was that the response to videos of stress and stress recovery were opposite in direction. More specifically, observers experienced heart rate deceleration when viewing videos of high stress, and heart rate acceleration when viewing videos of stress recovery. This difference highlights how context can shape the response in the observer. Much research on emotional contagion has exclusively looked for evidence of physiological synchrony. This focus on physiological synchrony has likely evolved from the research on behavioral synchrony and mimicry, for example, research showing interpersonal synchrony increases affiliation and liking (Hove & Risen, 2009). However, there is not much strong evidence to indicate that one-to-one physiological synchrony is the optimal way to experience affective sharing and engage in effective communication. In fact, there is a growing body of research that suggests just the opposite; that direct physiological synchrony can increase conflict (Gates et al., 2015; Liu et al., 2013; Timmons et al., 2015). While there existed significant group-wide differences between responses to stress and stress recovery videos, the responses to these videos were not all unidirectional. Some stress videos elicited heart rate acceleration and not deceleration, while some stress recovery videos elicited deceleration. This serves as a useful reminder that "stress" is not a neatly delineated internal state. When studying how observers respond to the stress of others, it is not only likely, but almost guaranteed, that the response patterns of observers will depend not only on the stress level of the speaker, but on a multitude of factors inherent to the speaker. In real-life interactions there is the added layer of existing relationships between the persons. Overall, this begs the question; which response is the most advantageous? No patterns involving individual differences in parasympathetic activity, empathy or psychopathy predicted any of these response patterns. It appears that the psychophysiological response to the distress of others is likely a lot more complex than direct physiological synchrony being related to levels of empathy. Synchrony is likely an overly simplistic pattern to expect. By using multiple videos in Study 1, I was able to determine how a number of different individuals responded to a number of different speaker. To my knowledge this is was also one of the first stress contagion studies in humans to use a repeated measures design. Doing so allowed me to assess these variations between observed speakers and stress levels. The advantage of using multiple stimuli is that it allows one to determine the average response from a number of individuals, to each different stimulus. As the average response to each stimulus is likely different, one can investigate the specific response had to each stimulus, so as to begin to gain a more fine-grained account of the suite of physiological responses to different types of individuals and stress levels. Once this is better understood, we can begin to determine which of these responses is most advantageous to empathic accuracy and understanding.

Altogether, the results from this study suggest assessing the distress of another is reliant on a number of interacting psychophysiological mechanisms. Observers must first experience physiological changes in response to the distress of others, and then rely on interoceptive mechanisms to assess the distress of the person in question. Empathic accuracy for detecting distress in others is likely related to three factors, namely: 1) emotional contagion, and the accompanying physiological response, 2) interoceptive accuracy and 3) reliance on interoceptive cues to make empathic judgments. If one experiences appropriate physiological changes in response to another's distress, and has high interoceptive accuracy, but does not intuitively know to use this ability, the two previous factors are likely not to have any predictive value toward one's empathic accuracy. I plan on studying this question in greater detail in future work. Much of empathic accuracy research has focused on identifying categorical emotions (Spunt & Adolphs, 2017). This current work focused on the degree instead of the category, a domain that cannot be overlooked in empathic accuracy research. Being able to infer the degree of distress one is experiencing is important for determining which behavior is most helpful. It is also important for one's own emotions; if one is regularly interpreting a high degree of distress in other's around them, the negative consequences of stress contagion may take hold. Indeed, future research should also explore how more chronic exposure to stress may be contagious, and what the health ramifications might be. It is undoubtedly important to feel the stress of others, as emotional contagion is a key component of empathic processing, however in some contexts, it can likely cross over into chronic stress in the recipient. This is especially likely in the case of someone who is overly empathetic and unable to remove themselves from the presence of someone under chronic stress (or someone whom they perceive to be under chronic stress).

In Study 2, I aimed to determine how others respond when observing someone being socially rejected. Unlike the Study 1, where behavior was not studied, it was the primary outcome variable of interest in Study 2. The main finding of this study is that following the observation of social rejection, individuals will altruistically punish the perpetrator. While there have been many studies that demonstrate the partial existence of altruistic punishment in humans (e.g. (Crockett et al., 2010; Shinada et al., 2004; Vinkers et al., 2013), the results have not been unanimous (Krasnow, Cosmides, Pedersen, & Tooby, 2012; Pedersen, Kurzban, & McCullough, 2013), and they have almost exclusively utilized economic games to create situations of unfairness. The results from Study 2 add to the evidence of altruistic punishment in humans, a costly behavior that provides no direct benefit to the actor. Social rejection research in humans has almost exclusively focused on the person experiencing it. Comparatively little research has investigated the reactions observers have to social rejection. Since there are often bystanders to instances of rejection, investigating reactions from bystanders help us to understand who might be most likely to help, and why. Study 2's results indicate that the physiological reaction when observing someone be rejected may play a role in later behavior. I found that heart rate deceleration when observing rejection later predicted likelihood of engaging in altruistic punishment. Furthermore, I found that a past history of bullying increased the likelihood of then punishing the bully. This adds to the past work that has found that past experiences can help with empathic responses to others in similar situations (Batson et al., 1996). However, dispositional empathy, did not predict altruistic punishment behavior. If anything, dispositional empathy made one somewhat less likely to punish. Just how empathy may get in the way of helping if one experiences too much personal distress, this finding adds to that by demonstrating that empathy might hinder one from seeking retributive justice on behalf of another, and thus, helping the victim from further harm.

In closing, I would like to draw attention to three main themes I found between the results of these two studies. Firstly, I found evidence for heart rate deceleration in response to the distress in others. In Study 1, when observing others experiencing high levels of stress, the overall physiological marker of response was a heart rate deceleration. Moreover, when observers made anxiety ratings of the speakers, their ratings were negatively related to their own heart rate. Thus, as they rated speakers as being more anxious, their heart rates when viewing the video were comparatively lower (as compared to their baseline). This suggests that one's own degree of heart rate deceleration in response to observing someone may play a role in how we assess their stress levels. In Study 2, participants who experienced heart rate deceleration in response to observing rejection were then more likely to altruistically punish the bully. This indicates how heart rate deceleration may be a marker of the emotional response to social rejection. Heart rate deceleration has been found in response to viewing a variety of aversive material (Hagenaars et al., 2014; Lang et al., 1993). Study 1 and Study 2 add to this by demonstrating that observing distress may be a similarly aversive experience, thus resulting in heart rate deceleration, and potentially motivating later behavior. The second theme was that of empathy, or more specifically, the lack thereof of interactions with empathy. My main findings, whether about stress contagion or social rejection, were mostly unrelated to dispositional empathy. These experiments undoubtedly were related to empathic processes. The lack of interactions with empathy likely indicate that within the normal population, quotidian inter-individual differences in empathy do not play a large role in these effects. The current two studies certainly found individual differences in the physiological reactions to the distress of others. Whether these reactions are due to other unmeasured variables, or because these empathic differences were not captured within the questionnaire we used, cannot be spoken to. Future research should investigate how these physiological reactions map onto other measures of empathy. Finally, another commonality between the results of the two studies was the increase in physiological variance seen in response to observing distress. More specifically, in Study 1, observing stress or stress recovery, and in Study 2, observing rejection, elicited more varied reactions than observing no stress in Study 1 or no rejection in Study 2. This shared finding illustrates that while observing stress or rejection elicited a physiological response in observers, they were not homogenous responses across observers. While heart rate deceleration was noted in both studies, it was not the response of all participants, or for all stress and stress recovery videos. This increase in variance brings attention to how we study affective reactions to distress. Oftentimes, a spotlight is put on synchrony, and hypotheses are built upon unidirectional effects. However, results from Study 1 and Study elucidate how participants may indeed have affective reactions, yet due to our current lack of understanding in how dispositional differences may affect these reactions, they may often be heterogeneous in nature, and thus not summarize into a unidirectional effect across participants. As John Cacioppo and Gary Bernston once put it, “the nature of the brain, behavior and society is […] orderly in its complexity rather than lawful in its simplicity” (1992). As such, while synchrony may provide the simplest pattern of association, one must seek order in a deeper complexity. I hope future research will consider this and avoid an overly narrow view of affective sharing and instead consider, and embrace more nuanced patterns of psychophysiological correspondence between individuals.

In conclusion, this work demonstrates evidence for physiological stress contagion, and a proclivity for altruistic punishment following observing social rejection, in adult humans. Results from these studies add to the literature on empathy, by demonstrating that humans experience physiological responses that likely reflect aversion, in response to the distress of others, or in short, emotional contagion, and these responses can then be related to empathic accuracy and later helping behavior. The two studies used observational experimental paradigms where participants observed others experiencing distress. I believe such an experimental set-up allows researchers to better understand the emotional responses to others, and adds to emotional research by considering emotions as they exist in the environment; socially. By studying how individuals respond to others, we can come closer to understanding why some individuals navigate their social environment with ease. As a social species, our well-being, health and happiness could be ameliorated if we could unlock the complicated psychophysiological mechanisms that underlie one basic skill; understanding the needs of one another.

REFERENCES

Adam, E. K., Hawkley, L. C., Kudielka, B. M., & Cacioppo, J. T. (2006). Day-to-day dynamics of experience--cortisol associations in a population-based sample of older adults. *Proceedings of the National Academy of Sciences of the United States of America*, *103*(45), 17058–63. http://doi.org/10.1073/pnas.0605053103

Adenauer, H., Catani, C., Keil, J., Aichinger, H., & Neuner, F. (2010). Is freezing an adaptive reaction to threat? Evidence from heart rate reactivity to emotional pictures in victims of war and torture. *Psychophysiology*, *47*(2), 315–322. http://doi.org/10.1111/j.1469-8986.2009.00940.x

Alexander, R. D. (1974). The evolution of social behavior. *Annual Review of Ecology and Systematics*, 325–383.

Andreou, E. (2004). Bully/victim problems and their association with Machiavellianism and self-efficacy in Greek primary school children. *British Journal of Educational Psychology*, *74*(2), 297–309. http://doi.org/10.1348/000709904773839897

Bänziger, T., Grandjean, D., & Scherer, K. R. (1979). Emotion Recognition From Expressions in Face, Voice, and Body: The Multimodal Emotion Recognition Test (MERT). *Diagnostic Analysis of Nonverbal Accuracy; Nowicki & Duke Emotion Recognition Index*. http://doi.org/10.1037/a0017088

Bänziger, T., & Scherer, K. R. (2005). The role of intonation in emotional expressions. *Speech Communication*, *46*(3), 252–267. http://doi.org/10.1016/j.specom.2005.02.016

Barnett, M. A., Tetreault, P. A., & Masbad, I. (1987). Empathy with a Rape Victim: The Role of Similarity of Experience. *Violence and Victims*, *2*(4), 255–62.

Batson, C. D. (1990). How social an animal? The human capacity for caring. *American Psychologist*, *45*, 336–346. http://doi.org/10.1037/0003-066X.45.3.336

Batson, C. D., Fultz, J., & & Schoenrade, P. A. (1987). Adults' emotional reactions to the distress of others. In & J. S. N. Eisenberg (Ed.), *Empathy and its development* (pp. 163–184). Cambridge: Cambridge University Press.

Batson, C. D., Sympson, S. C., Hindman, J. L., Decruz, P., Todd, R. M., Weeks, J. L., … Burris, C. T. (1996). "I've Been There, Too" Effect on Empathy of Prior Experience With a Need. *Personality and Social Psychology Bulletin*, *22*(5), 474–482. http://doi.org/10.1177/0146167296225005

Baumeister, R. F., & Leary, M. R. (1995). The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation. *Psychological Bulletin*, *117*(3), 497–529. http://doi.org/10.1037/0033-2909.117.3.497

Ben-Ami Bartal, I., Decety, J., & Mason, P. (2011). Empathy and Pro-Social Behavior in Rats.

Science, *334*, 1427. http://doi.org/10.1126/science.1210789

Benning, S. D., Patrick, C. J., Hicks, B. M., Blonigen, D. M., & Krueger, R. F. (2003). Factor Structure of the Psychopathic Personality Inventory: Validity and Implications for Clinical Assessment. *Psychological Assessment*, *15*(3), 340–350. http://doi.org/10.1037/1040-3590.15.3.340

Bernston, G. G., Bigger, J. T., Eckberg, D. L., Grossman, P., Kaufman, P. G., Malik, M., … Van der Molen, M. W. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology*, *34*, 623–648. http://doi.org/10.1111/j.1469-8986.1997.tb02140.x

Bernston, G. G., Cacioppo, J. T., Binkley, P. F., Uchino, B. N., Quigley, K. S., & Fieldstone, A. (1994). Autonomic cardiac control. III. Psychological stress and cardiac response in autonomic space as revealed by pharmacological blockades. *Psychophysiology*, *31*, 599–608. http://doi.org/10.1111/j.1469-8986.1994.tb02352.x

Bingel, U., Schoell, E., Herken, W., & May, A. (2007). Habituation to painful stimulation involves the antinociceptive system. *Pain*, *131*(1–2), 21–30. http://doi.org/10.1016/J.PAIN.2006.12.005

Blackhart, G. C., Eckel, L. A., & Tice, D. M. (2007). Salivary cortisol in response to acute social rejection and acceptance by peers. *Biological Psychology*, *75*(3), 76–81. http://doi.org/10.1016/j.biopsycho.2007.03.005

Brouwer, A.-M., van Wouwe, N., Mühl, C., van Erp, J., & Toet, A. (2013). Perceiving blocks of emotional pictures and sounds: effects on physiological variables. *Frontiers in Human Neuroscience*, *7*, 295. http://doi.org/10.3389/fnhum.2013.00295

Brown, J. L., Sheffield, D., Leary, M., & Robinson, M. (2003). Social Support and Experimental Pain : Psychosomatic Medicine. *Psychosomatic Medicine*, *65*(2), 276–283. http://doi.org/10.1097/01.PSY.0000030388.62434.46

Brown, S. L., Nesse, R. M., Vinokur, A. D., & Smith, D. M. (2003). Providing Social Support May Be More Beneficial Than Receiving It. *Psychological Science*, *14*(4), 320–327. http://doi.org/10.1111/1467-9280.14461

Buchanan, T. W., Bagley, S. L., Stansfield, R. B., & Preston, S. D. (2011). The empathic, physiological resonance of stress. *Social Neuroscience*, *7*(2), 191–201. http://doi.org/10.1080/17470919.2011.588723

Buckley, K. E., Winkel, R. E., & Leary, M. R. (2004). Reactions to acceptance and rejection: Effects of level and sequence of relational evaluation. *Journal of Experimental Social Psychology*, *40*(1), 14–28. http://doi.org/10.1016/S0022-1031(03)00064-7

Butler, E. A. (2015). Interpersonal Affect Dynamics: It Takes Two (and Time) to Tango. *Emotion Review*, *7*(4), 336–341. http://doi.org/10.1177/1754073915590622

Butler, E. A. (2017). Emotions are temporal interpersonal systems. *Current Opinion in*

Psychology, *17*, 129–134. http://doi.org/10.1016/j.copsyc.2017.07.005

Butler, E. A., & Randall, A. K. (2012). Emotional Coregulaton in Close Relationships. *Emotion Review*, *5*(2), 202–210. http://doi.org/10.1177/1754073912451630

Butler, E. A., Wilhelm, F. H., & Gross, J. J. (2006). Respiratory sinus arrhythmia, emotion, and emotion regulation during social interaction. *Psychophysiology*, *43*(6), 612–622. http://doi.org/10.1111/j.1469-8986.2006.00467.x

Byrne, R., Lee, P. C., Njiraini, N., Poole, J. H., Sayialel, K., Sayialel, S., … Moss, C. J. (2008). Do Elephants Show Empathy? *Journal of Consciousness Studies, 15*, 204–255.

Cacioppo, J. T. (1994). Social neuroscience: Autonomic, neuroendocrine, and immune responses to stress. *Psychophysiology*, *31*, 113–128.

Cacioppo, J. T., Bernston, G. G., Larsen, J. T., Poehlmann, K. M., & Ito, T. A. (2000). The Psychophysiology of Emotion. In *Handbook of Emotions* (pp. 173–191).

Cacioppo, J. T., & Berntson, G. G. (1992). Social psychological contributions to the decade of the brain: Doctrine of multilevel analysis. *American Psychologist*, *47*(8), 1019–1028. http://doi.org/10.1037/0003-066X.47.8.1019

Cacioppo, J. T., Ernst, J. M., Burleson, M. H., McClintock, M. K., Malarkey, W. B., Hawkley, L. C., … Bernston, G. G. (2000). Lonely traits and concomitant physiological processes: the MacArthur social neuroscience studies. *International Journal of Psychophysiology, 35*, 143–154. http://doi.org/10.1016/S0167-8760(99)00049-5

Cacioppo, J. T., & Hawkley, L. C. (2009). Perceived social isolation and cognition. *Trends in Cognitive Sciences*, *13*(10), 447–54. http://doi.org/10.1016/j.tics.2009.06.005

Cacioppo, J. T., Hawkley, L. C., Ernst, J. M., Burleson, M., Berntson, G. G., Nouriani, B., & Spiegel, D. (2006). Loneliness within a nomological net: An evolutionary perspective. *Journal of Research in Personality*, *40*(6), 1054–1085. http://doi.org/10.1016/j.jrp.2005.11.007

Cacioppo, S., Zhou, H., Monteleone, G., Majka, E. A., Quinn, K. A., Ball, A. B., … Cacioppo, J. T. (2014). You are in sync with me: neural correlates of interpersonal synchrony with a partner. *Neuroscience*, *277*, 842–858. http://doi.org/10.1016/j.neuroscience.2014.07.051

Carlsmith, K. M., Darley, J. M., & Robinson, P. H. (2002). Why Do We Punish? Deterrence and Just Deserts as Motives for Punishment. *Journal of Personality and Social Psychology*, *83*(2), 284–299. http://doi.org/10.1037//0022-3514.83.2.284

Carnevali, L., Montano, N., Statello, R., Coudé, G., Vacondio, F., Rivara, S., … Sgoifo, A. (2017). Social stress contagion in rats: Behavioural, autonomic and neuroendocrine correlates. *Psychoneuroendocrinology*, *82*, 155–163. http://doi.org/10.1016/j.psyneuen.2017.05.017

Carrera, P., Oceja, L., Caballero, A., Muñoz, D., López-Pérez, B., & Ambrona, T. (2013). I feel so sorry! Tapping the joint influence of empathy and personal distress on helping behavior. *Motivation and Emotion*, *37*(2), 335–345. http://doi.org/10.1007/s11031-012-9302-9

Clay, Z., de Waal, F. B. M., Hare, B., Beck, A., & Ivan, K. (2013). Bonobos Respond to Distress in Others: Consolation across the Age Spectrum. *PLoS ONE*, *8*(1), e55206. http://doi.org/10.1371/journal.pone.0055206

Cools, A. K. A., Van Hout, A. J.-M., & Nelissen, M. H. J. (2008). Canine Reconciliation and Third-Party-Initiated Postconflict Affiliation: Do Peacemaking Social Mechanisms in Dogs Rival Those of Higher Primates? *Ethology*, *114*(1), 53–63. http://doi.org/10.1111/j.1439-0310.2007.01443.x

Copeland, W. E., Wolke, D., Lereya, S. T., Shanahan, L., Worthman, C., & Costello, E. J. (2014). Childhood bullying involvement predicts low-grade systemic inflammation into adulthood. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(21), 7570–5. http://doi.org/10.1073/pnas.1323641111

Cordoni, G., Palagi, E., & Tarli, S. B. (2006). Reconciliation and Consolation in Captive Western Gorillas. *International Journal of Primatology*, *27*(5), 1365–1382. http://doi.org/10.1007/s10764-006-9078-4

Côté, S., & Miners, C. T. H. (2006). Emotional Intelligence, Cognitive Intelligence, and Job Performance. *Administrative Science Quarterly*, *51*(1), 1–28. http://doi.org/10.2189/asqu.51.1.1

Crockett, M. J., Clark, L., Lieberman, M. D., Tabibnia, G., & Robbins, T. W. (2010). Impulsive choice and altruistic punishment are correlated and increase in tandem with serotonin depletion. *Emotion (Washington, D.C.)*, *10*(6), 855–62. http://doi.org/10.1037/a0019861

Danziger, N., Prkachin, K. M., & Willer, J.-C. (2006). Is pain the price of empathy? The perception of others' pain in patients with congenital insensitivity to pain. *Brain*, *129*(9), 2494–2507. http://doi.org/10.1093/brain/awl155

Decety, J. (2011). The neuroevolution of empathy. *Annals of the New York Academy of Sciences*, *1231*(1), 35–45. http://doi.org/10.1111/j.1749-6632.2011.06027.x

Decety, J., & Jackson, P. L. (2004). The functional architecture of human empathy. In J. T. Cacioppo & G. G. Bernston (Eds.), *Behavioral and cognitive neuroscience reviews* (Vol. 3, pp. 71–100). New York: Wiley. http://doi.org/10.1177/1534582304267187

Decety, J., & Lamm, C. (2009). The Biological Bases of Empathy.

Decety, J., & Meyer, M. (2008). From emotion resonance to empathic understanding: A social developmental neuroscience account. *Developmental Psychopathology*, *20*(4), 1053–1080. http://doi.org/10.1017/S0954579408000503

Decety, J., Norman, G. J., Berntson, G. G., & Cacioppo, J. T. (2012). A neurobehavioral evolutionary perspective on the mechanisms underlying empathy. *Progress in Neurobiology*, *98*(1), 38–48. http://doi.org/10.1016/j.pneurobio.2012.05.001

Dewall, C. N., Twenge, J. M., Bushman, B., Im, C., & Williams, K. (2010). A Little Acceptance Goes a Long Way: Applying Social Impact Theory to the Rejection–Aggression Link. *Social Psychological and Personality Science*, *1*(2), 168–174. http://doi.org/10.1177/1948550610361387

Duncan, S., & Barrett, L. F. (2007). Affect is a form of cognition: A neurobiological analysis. *Cognition & Emotion*, *21*(6), 1184–1211. http://doi.org/10.1080/02699930701437931

Edgar, J. L., Lowe, J. C., Paul, E. S., & Nicol, C. J. (2011). Avian maternal response to chick distress. *Proceedings. Biological Sciences*, *278*(1721), 3129–34. http://doi.org/10.1098/rspb.2010.2701

Eisenberg, N., Fabes, R. A., Miller, P. A., Fultz, J., Shell, R., Mathy, R. M., & Reno, R. R. (1989). Relation of Sympathy and Personal Distress to Prosocial Behavior: A Multimethod Study. *Interpersonal Relations and Group Processes*, *57*(1), 55–66. http://doi.org/10.1037/0022-3514.57.1.55

Eisenberg, N., & Strayer, J. (1987). *Evolutionary bases of empathy: Empathy and its development*. Cambridge, NY: Cambridge University Press.

Eisenberger, N. I., Jarcho, J. M., Lieberman, M. D., & Naliboff, B. D. (2006). An experimental study of shared sensitivity to physical pain and social rejection. *Pain*, *126*(1–3), 132–138. http://doi.org/10.1016/J.PAIN.2006.06.024

Eklund, J., Andersson-Straberg, T., & Hansen, E. M. (2009). “I’ve also experienced loss and fear”: Effects of prior similar experience on empathy. *Scandinavian Journal of Psychology*, *50*(1), 65–69. http://doi.org/10.1111/j.1467-9450.2008.00673.x

Ekman, P., & Paul. (1993). Facial expression and emotion. *American Psychologist*, *48*(4), 384–392. http://doi.org/10.1037/0003-066X.48.4.384

Elfenbein, H. A., Foo, M. Der, White, J., Tan, H. H., & Aik, V. C. (2007). Reading your Counterpart: The Benefit of Emotion Recognition Accuracy for Effectiveness in Negotiation. *Journal of Nonverbal Behavior*, *31*(4), 205–223. http://doi.org/10.1007/s10919-007-0033-7

Engel, C. (2011). Dictator games: a meta study. *Experimental Economics*, *14*(4), 583–610. http://doi.org/10.1007/s10683-011-9283-7

Engert, V., Plessow, F., Miller, R., Kirschbaum, C., & Singer, T. (2014). Cortisol increase in empathic stress is modulated by emotional closeness and observation modality. *Psychoneuroendocrinology*, *45*(45), 192–201. http://doi.org/10.1016/j.psyneuen.2014.04.005

Fehr, E., & Gächter, S. (2000). Cooperation and Punishment in Public Goods Experiments.

Source: The American Economic Review, *90*(4), 980–994. Retrieved from http://dx.doi.org/10.1257/aer.90.4.980

Fehr, E., & Gächter, S. (2002). Altruistic punishment in humans. *Nature*, *415*(6868), 137–140. http://doi.org/10.1038/415137a

Fischer, A. H., & Manstead, A. S. R. (2008). Social functions of emotion. In M. Lewis, J. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of Emotions* (3rd ed., pp. 456–468). New York: Guilford Press.

Fowler, J. H. (2005). Altruistic punishment and the origin of cooperation. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(19), 7047–9. http://doi.org/10.1073/pnas.0500938102

Fraser, O. N., Bugnyar, T., Knight, T., Schaumburg, K., & Heinrich, B. (2010). Do Ravens Show Consolation? Responses to Distressed Others. *PLoS ONE*, *5*(5), e10605. http://doi.org/10.1371/journal.pone.0010605

Fraser, O. N., Stahl, D., & Aureli, F. (2008). Stress reduction through consolation in chimpanzees. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(25), 8557–62. http://doi.org/10.1073/pnas.0804141105

Gates, K. M., Gatzke-Kopp, L. M., Sandsten, M., & Blandon, A. Y. (2015). Estimating time-varying RSA to examine psychophysiological linkage of marital dyads. *Psychophysiology*, *52*(8), 1059–1065. http://doi.org/10.1111/psyp.12428

Gleason, K. A., Jensen-Campbell, L. A., & Ickes, W. (2009). The Role of Empathic Accuracy in Adolescents' Peer Relations and Adjustment. *Personality and Social Psychology Bulletin*, *35*(8), 997–1011. http://doi.org/10.1177/0146167209336605

Goumon, S., & Špinka, M. (2016). Emotional contagion of distress in young pigs is potentiated by previous exposure to the same stressor. *Animal Cognition*, *19*(3), 501–11. http://doi.org/10.1007/s10071-015-0950-5

Graham, F. K., & Clifton, R. K. (1966). Heart-rate change as a component of the orienting response. *Psychological Bulletin*, *65*(5), 305–320. http://doi.org/10.1037/h0023258

Hagenaars, M. A., Roelofs, K., & Stins, J. F. (2014). Human freezing in response to affective films. *Anxiety, Stress, & Coping*, *27*(1), 27–37. http://doi.org/10.1080/10615806.2013.809420

Hare, R. D., & Blevings, G. (1975). Defensive responses to phobic stimuli. *Biological Psychology*, *3*(1), 1–13. http://doi.org/10.1016/0301-0511(75)90002-2

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). *Emotional contagion*. New York, NY: Cambridge University Press.

Hawkley, L. C., & Cacioppo, J. T. (2010). Loneliness matters: a theoretical and empirical review of consequences and mechanisms. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*, *40*(2), 218–27. http://doi.org/10.1007/s12160-010-9210-8

Hawkley, L. C., Thisted, R. A., Masi, C. M., & Cacioppo, J. T. (2010). Loneliness predicts increased blood pressure: 5-year cross-lagged analyses in middle-aged and older adults. *Psychology and Aging*, *25*(1), 132–141. http://doi.org/10.1037/a0017805

Haynes, S. N., Gannon, L. R., Orimoto, L., O'Brien, W. H., & et al. (1991). Psychophysiological assessment of poststress recovery. *Psychological Assessment*, *3*(3), 356–365. http://doi.org/10.1037/1040-3590.3.3.356

Hein, G., Silani, G., Preuschoff, K., Batson, C. D., & Singer, T. (2010). Neural Responses to Ingroup and Outgroup Members' Suffering Predict Individual Differences in Costly Helping. *Neuron*, *68*(1), 149–160. Retrieved from http://www.sciencedirect.com/science/article/pii/S0896627310007208

Hertel, J., Schütz, A., & Lammers, C.-H. (2009). Emotional Intelligence and Mental Disorder Claas-Hinrich Lammers. *J Clin Psychol*, *65*(9), 942–954. http://doi.org/10.1002/jclp.20597

Hodges, S. D., Kiel, K. J., Kramer, A. D. I., Veach, D., & Villanueva, B. R. (2010). Giving Birth to Empathy: The Effects of Similar Experience on Empathic Accuracy, Empathic Concern, and Perceived Empathy. *Personality and Social Psychology Bulletin*, *36*(3), 398–409. http://doi.org/10.1177/0146167209350326

Holt-Lunstad, J., Smith, T. B., Layton, J. B., Rabin, B., Gwaltney, J., Kobayakawa, M., … Uchitomi, Y. (2010). Social Relationships and Mortality Risk: A Meta-analytic Review. *PLoS Medicine*, *7*(7), e1000316. http://doi.org/10.1371/journal.pmed.1000316

Holwerda, T. J., Deeg, D. J. H., Beekman, A. T. F., van Tilburg, T. G., Stek, M. L., Jonker, C., & Schoevers, R. A. (2014). Feelings of loneliness, but not social isolation, predict dementia onset: results from the Amsterdam Study of the Elderly (AMSTEL). *Journal of Neurology, Neurosurgery, and Psychiatry*, *85*(2), 135–42. http://doi.org/10.1136/jnnp-2012-302755

Hove, M. J., & Risen, J. L. (2009). It's All in the Timing: Interpersonal Synchrony Increases Affiliation. *Social Cognition*, *27*(6), 949–960. http://doi.org/10.1521/soco.2009.27.6.949

Hu, Y., Strang, S., & Weber, B. (2015). Helping or punishing strangers: neural correlates of altruistic decisions as third-party and of its relation to empathic concern. *Frontiers in Behavioral Neuroscience*, *9*, 24. http://doi.org/10.3389/fnbeh.2015.00024

Ickes, W. (1997). *Empathic Accuracy*. New York: The Guilford Press. Retrieved from https://books.google.com/books?hl=en&lr=&id=-7ob3yJdFqQC&oi=fnd&pg=PA1&dq=ickes+1997&ots=YX_oCszipY&sig=Hx0Of9UXAQCPBKwZoavd8FmhpCM#v=onepage&q=ickes 1997&f=false

Jackson, P. L., Meltzoff, A. N., & Decety, J. (2004). How do we perceive the pain of others? A window into the neural processes involved in empathy. http://doi.org/10.1016/j.neuroimage.2004.09.006

Jeon, D., Kim, S., Chetana, M., Jo, D., Ruley, H. E., Lin, S.-Y., … Shin, H.-S. (2010). Observational fear learning involves affective pain system and Cav1.2 Ca2+ channels in ACC. *Nature Neuroscience*, *13*(4), 482–488. http://doi.org/10.1038/nn.2504

Juster, R.-P., McEwen, B. S., & Lupien, S. J. (2010). Allostatic load biomarkers of chronic stress and impact on health and cognition. *Neuroscience & Biobehavioral Reviews*, *35*(1), 2–16. http://doi.org/10.1016/J.NEUBIOREV.2009.10.002

Kardos, P., Leidner, B., Pléh, C., Soltész, P., & Unoka, Z. (2017). Empathic people have more friends: Empathic abilities predict social network size and position in social network predicts empathic efforts. *Social Networks*, *50*, 1–5. http://doi.org/10.1016/j.socnet.2017.01.004

Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The "Trier Social Stress Test"--a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*(1–2), 76–81. http://doi.org/119004

Krach, S., Cohrs, J. C., de Echeverría Loebell, N. C., Kircher, T., Sommer, J., Jansen, A., & Paulus, F. M. (2011). Your Flaws Are My Pain: Linking Empathy To Vicarious Embarrassment. *PLoS ONE*, *6*(4), e18675. http://doi.org/10.1371/journal.pone.0018675

Krasnow, M. M., Cosmides, L., Pedersen, E. J., & Tooby, J. (2012). What Are Punishment and Reputation for? *PLoS ONE*, *7*(9), e45662. http://doi.org/10.1371/journal.pone.0045662

Lamm, C., Porges, E. C., Cacioppo, J. T., & Decety, J. (2008). Perspective taking is associated with specific facial responses during empathy for pain. http://doi.org/10.1016/j.brainres.2008.06.066

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, *30*(3), 261–273. http://doi.org/10.1111/j.1469-8986.1993.tb03352.x

Leliveld, M. C., Dijk, E., & Beest, I. (2012). Punishing and compensating others at your own expense: The role of empathic concern on reactions to distributive injustice. *European Journal of Social Psychology*, *42*(2), 135–140. http://doi.org/10.1002/ejsp.872

LeRoy, A. S., Murdock, K. W., Jaremka, L. M., Loya, A., & Fagundes, C. P. (2017). Loneliness predicts self-reported cold symptoms after a viral challenge. *Health Psychology*, *36*(5), 512–520. http://doi.org/10.1037/hea0000467

Levenson, R. W., & Ruef, A. M. (1992). Empathy: A Physiological Substrate. *Journal of Personality and Social Psychology*, *63*(2), 234–246. Retrieved from https://pdfs.semanticscholar.org/a36c/bc62d4420a788b07c3193f54d2083b220d4d.pdf

Lilienfeld, S. O., & Widows, M. R. (2005). *Psychopathic Personality Inventory—Revised (PPI-R) professional manual*. Lutz, FL: Psychological Assessment Resources. Retrieved from https://www.parinc.com/WebUploads/samplerpts/PPI-R_SP_Sample.pdf

Liu, S., Rovine, M. J., Cousino Klein, L., & Almeida, D. M. (2013). Synchrony of diurnal cortisol pattern in couples. *Journal of Family Psychology*, *27*(4), 579–588. http://doi.org/10.1037/a0033735

Lopez-Martinez, A. E., Esteve-Zarazaga, R., & Ramirez-Maestre, C. (2008). Perceived Social Support and Coping Responses Are Independent Variables Explaining Pain Adjustment Among Chronic Pain Patients. *The Journal of Pain*, *9*(4), 373–379. Retrieved from http://ac.els-cdn.com/S1526590007010280/1-s2.0-S1526590007010280-main.pdf?_tid=d670d6b6-6dc0-11e7-9bb6-00000aab0f01&acdnat=1500606245_13e82ef8ec181b9d12ed85b3bdbc70bf

Lovell, B., & Wetherell, M. A. (2011). The cost of caregiving: Endocrine and immune implications in elderly and non elderly caregivers. *Neuroscience & Biobehavioral Reviews*, *35*(6), 1342–1352. http://doi.org/10.1016/j.neubiorev.2011.02.007

Luhmann, M., & Eid, M. (2009). Does It Really Feel the Same? Changes in Life Satisfaction Following Repeated Life Events. *Journal of Personality and Social Psychology*, *97*(2), 363–381. http://doi.org/10.1037/a0015809

Luo, Y., Hawkley, L. C., Waite, L. J., & Cacioppo, J. T. (2012). Loneliness, health, and mortality in old age: a national longitudinal study. *Social Science & Medicine (1982)*, *74*(6), 907–14. http://doi.org/10.1016/j.socscimed.2011.11.028

Maneta, E. K., Cohen, S., Schulz, M. S., & Waldinger, R. J. (2015). Linkages between childhood emotional abuse and marital satisfaction: The mediating role of empathic accuracy for hostile emotions. *Child Abuse & Neglect*, *44*, 8–17. http://doi.org/10.1016/j.chiabu.2014.07.017

Marsh, K. L., Richardson, M. J., & Schmidt, R. C. (2009). Social Connection Through Joint Action and Interpersonal Coordination. *Topics in Cognitive Science*, *1*(2), 320–339. http://doi.org/10.1111/j.1756-8765.2009.01022.x

Masui, K., Iriguchi, S., Nomura, M., & Ura, M. (2011). Amount of altruistic punishment accounts for subsequent emotional gratification in participants with primary psychopathy. *Personality and Individual Differences*, *51*(7), 823–828. http://doi.org/10.1016/J.PAID.2011.07.006

McEwen, B. S., & Gianaros, P. J. (2010). Central role of the brain in stress and adaptation: Links to socioeconomic status, health, and disease. *Annals of the New York Academy of Sciences*, *1186*(1), 190–222. http://doi.org/10.1111/j.1749-6632.2009.05331.x

Nezlek, J. B., Wesselmann, E. D., Wheeler, L., & Williams, K. D. (2012). Ostracism in Everyday Life. *Group Dynamics: Theory, Research and Practice*, *16*(2), 91–104. http://doi.org/10.1037/a0028029

Norman, G. J., Berntson, G. G., & Cacioppo, J. T. (2014). Emotion, Somatovisceral Afference, and Autonomic Regulation. *Emotion Review*, *6*(2), 113–123. http://doi.org/10.1177/1754073913512006

Norman, G. J., Karelina, K., Morris, J. S., Zhang, N., Cochran, M., & Courtney DeVries, A. (2010). Social Interaction Prevents the Development of Depressive-Like Behavior Post Nerve Injury in Mice: A Potential Role for Oxytocin. *Psychosomatic Medicine*, *72*(6), 519–526. http://doi.org/10.1097/PSY.0b013e3181de8678

Ochsner. (2017). Helping Others Regulate Emotion Predicts Increased Regulation of One's Own Emotions and Decreased Symptoms of Depression. *JPSP*. http://doi.org/10.1177/0146167217695558

Öhman, A., Hamm, A., & Hugdahl, K. (2000). Cognition and the autonomic nervous system: Orienting, anticipation, and conditioning. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (pp. 533–575). New York, NY: Cambridge University Press. Retrieved from http://psycnet.apa.org/record/2000-03927-019

Osvath, M., & Sima, M. (2014). Sub-adult Ravens Synchronize their Play: A Case of Emotional Contagion? *ABC Animal Behavior and Cognition*, *2014*(12), 197–205. http://doi.org/10.12966/abc

Palumbo, R. V., Marraccini, M. E., Weyandt, L. L., Wilder-Smith, O., McGee, H. A., Liu, S., & Goodwin, M. S. (2017). Interpersonal Autonomic Physiology: A Systematic Review of the Literature. *Personality and Social Psychology Review*, *21*(2), 99–141. http://doi.org/10.1177/1088868316628405

Pedersen, E. J., Kurzban, R., & McCullough, M. E. (2013). Do humans really punish altruistically? A closer look. *Proceedings of the Royal Society of London B: Biological Sciences*, *280*(1758). Retrieved from http://rspb.royalsocietypublishing.org/content/280/1758/20122723.short

Perren, S., & Alsaker, F. D. (2006). Social behavior and peer relationships of victims, bully-victims, and bullies in kindergarten. *Journal of Child Psychology and Psychiatry*, *47*(1), 45–57. http://doi.org/10.1111/j.1469-7610.2005.01445.x

Porges, S. W., Doussard-Roosevelt, J. A., & Maiti, A. K. (1994). Vagal Tone and the Physiological Regulation of Emotion. *Source: Monographs of the Society for Research in Child Development*, *593*(2), 167–186. Retrieved from http://www.jstor.org/stable/1166144

Prati, G., & Pietrantoni, L. (2009). Optimism, Social Support, and Coping Strategies As Factors Contributing to Posttraumatic Growth: A Meta-Analysis. *Journal of Loss and Trauma*, *14*(5), 364–388. http://doi.org/10.1080/15325020902724271

Pressman, S. D., Cohen, S., Miller, G. E., Barkin, A., Rabin, B. S., & Treanor, J. J. (2005). Loneliness, Social Network Size, and Immune Response to Influenza Vaccination in College Freshmen. *Health Psychology*, *24*(3), 297–306. http://doi.org/10.1037/0278-6133.24.3.297

Reniers, R. L. E. P., Corcoran, R., Drake, R., Shryane, N. M., & Völlm, B. A. (2011). The QCAE: A Questionnaire of Cognitive and Affective Empathy. *Journal of Personality Assessment*, *93*(1), 84–95. http://doi.org/10.1080/00223891.2010.528484

Rimé, B. (2009). Emotion Elicits the Social Sharing of Emotion: Theory and Empirical Review. *Emotion Review*, *1*(1), 60–85. http://doi.org/10.1177/1754073908097189

Roberts, M. H., Klatzkin, R. R., & Mechlin, B. (2015). Social Support Attenuates Physiological Stress Responses and Experimental Pain Sensitivity to Cold Pressor Pain. *Annals of Behavioral Medicine*, *49*(4), 557–569. http://doi.org/10.1007/s12160-015-9686-3

Rubin, R. S., Munz, D. C., & Bommer, W. H. (2005). Leading from within: The Effects of Emotion Recognition and Personality on Transformational Leadership Behavior. *The Academy of Management Journal*. Academy of Management. http://doi.org/10.2307/20159701

Ruiz-Padial, E., Vila, J., & Thayer, J. F. (2011). The effect of conscious and non-conscious presentation of biologically relevant emotion pictures on emotion modulated startle and phasic heart rate. *International Journal of Psychophysiology*, *79*(3), 341–346. http://doi.org/10.1016/J.IJPSYCHO.2010.12.001

Sansone, R. A., Watts, D. A., & Wiederman, M. W. (2014). Being bullied in childhood, and pain and pain perception in adulthood. *The International Journal of Social Psychiatry*, *60*(5), 449–53. http://doi.org/10.1177/0020764013495526

Sarma, E. A., Kawachi, I., Poole, E. M., Tworoger, S. S., Giovannucci, E. L., Fuchs, C. S., & Bao, Y. (2018). Social integration and survival after diagnosis of colorectal cancer. *Cancer*, *124*(4), 833–840. http://doi.org/10.1002/cncr.31117

Schroevers, M. J., Helgeson, V. S., Sanderman, R., & Ranchor, A. V. (2010). Type of social support matters for prediction of posttraumatic growth among cancer survivors. *Psycho-Oncology*, *19*(1), 46–53. http://doi.org/10.1002/pon.1501

Seery, M. D. (2011). Challenge or threat? Cardiovascular indexes of resilience and vulnerability to potential stress in humans. *Neuroscience & Biobehavioral Reviews*, *35*(7), 1603–1610. http://doi.org/10.1016/j.neubiorev.2011.03.003

Shinada, M., Yamagishi, T., & Ohmura, Y. (2004). False friends are worse than bitter enemies: Altruistic punishment of in-group members. *Evolution and Human Behavior*, *25*(6), 379–393. http://doi.org/https://doi.org/10.1016/j.evolhumbehav.2004.08.001

Simpson, J. A., Kim, J. S., Fillo, J., Ickes, W., Rholes, W. S., Oriña, M. M., & Winterheld, H. A. (2011). Attachment and the Management of Empathic Accuracy in Relationship-Threatening Situations. *Article Personality and Social Psychology Bulletin*, *37*(2), 242–254. http://doi.org/10.1177/0146167210394368

Slavich, G. M., Way, B. M., Eisenberger, N. I., & Taylor, S. E. (2010). Neural sensitivity to social rejection is associated with inflammatory responses to social stress. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(33), 14817–22. http://doi.org/10.1073/pnas.1009164107

Sokolov, E. N. (1963). Higher Nervous Functions: The Orienting Reflex. *Annual Review of*

Physiology, *25*(1), 545–580. http://doi.org/10.1146/annurev.ph.25.030163.002553

Spunt, R. P., & Adolphs, R. (2017). The neuroscience of understanding the emotions of others. *Neuroscience Letters*. http://doi.org/10.1016/J.NEULET.2017.06.018

Strine, T. W., Kroenke, K., Dhingra, S., Balluz, L. S., Gonzalez, O., Berry, J. T., & Mokdad, A. H. (2009). The Associations Between Depression, Health-Related Quality of Life, Social Support, Life Satisfaction, and Disability in Community-Dwelling US Adults. *The Journal of Nervous and Mental Disease*, *197*(1), 61–64. http://doi.org/10.1097/NMD.0b013e3181924ad8

Strobel, A., Zimmermann, J., Schmitz, A., Reuter, M., Lis, S., Windmann, S., & Kirsch, P. (2011). Beyond revenge: Neural and genetic bases of altruistic punishment. *NeuroImage*. Retrieved from https://doi.org/10.1016/j.neuroimage.2010.07.051

Takizawa, R., Maughan, B., & Arseneault, L. (2014). Adult Health Outcomes of Childhood Bullying Victimization: Evidence From a Five-Decade Longitudinal British Birth Cohort. *The American Journal of Psychiatry*, *171*(7), 777–784. Retrieved from https://doi.org/10.1176/appi.ajp.2014.14040466

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews*, *36*(2), 747–756. http://doi.org/10.1016/j.neubiorev.2011.11.009

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders*, *61*(3), 201–216. http://doi.org/10.1016/S0165-0327(00)00338-4

Thoits, P. A. (2011). Mechanisms Linking Social Ties and Support to Physical and Mental Health. *Journal of Health and Social Behavior*, *52*(2), 145–161. http://doi.org/10.1177/0022146510395592

Thomas, P. A. (2010). Is It Better to Give or to Receive? Social Support and the Well-being of Older Adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *65B*(3), 351–357. http://doi.org/10.1093/geronb/gbp113

Timmons, A. C., Margolin, G., & Saxbe, D. E. (2015). Physiological Linkage in Couples and Its Implications for Individual and Interpersonal Functioning: A Literature Review Physiological Linkage in Couples and Its Implications for Individual and Interpersonal Functioning: A Literature Review. *Journal of Family Psychology*. http://doi.org/10.1037/fam0000115

Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The Relationship Between Social Support and Physiological Processes: A Review With Emphasis on Underlying Mechanisms and Implications for Health. *Psychological Bulletin*, *119*(3), 488–531. http://doi.org/10.1037/0033-2909.119.3.488

Van Breukelen, G. J. P., & Van Dijk, K. R. A. (2007). Use of covariates in randomized controlled trials. *Journal of the International Neuropsychological Society*, *13*(5), 903–904. http://doi.org/10.1017/S1355617707071147

Vinciarelli, A., & Bourlard, H. (2009). Social signal processing: Survey of an emerging domain. *Image and Vision Computing*, *27*(12), 1743–1759. http://doi.org/10.1016/J.IMAVIS.2008.11.007

Vinkers, C. H., Zorn, J. V., Cornelisse, S., Koot, S., Houtepen, L. C., Olivier, B., … Joëls, M. (2013). Time-dependent changes in altruistic punishment following stress. *Psychoneuroendocrinology*, *38*(9), 1467–1475. http://doi.org/10.1016/j.psyneuen.2012.12.012

Vollhardt, J. R. (2009). Altruism Born of Suffering and Prosocial Behavior Following Adverse Life Events: A Review and Conceptualization. *Social Justice Research*, *22*, 53–97. Retrieved from http://doi.org/10.1007/s11211-009-0088-1

Waldinger, R. J., & Schulz, M. S. (2010). What's love got to do with it? Social functioning, perceived health, and daily happiness in married octogenarians. *Psychology and Aging*, *25*(2), 422–31. http://doi.org/10.1037/a0019087

Waldinger, R. J., Schulz, M. S., Hauser, S. T., Allen, J. P., & Crowell, J. A. (2004). Reading Others' Emotions: The Role of Intuitive Judgments in Predicting Marital Satisfaction, Quality, and Stability. *Journal of Family Psychology*, *18*(1), 58–71. http://doi.org/10.1037/0893-3200.18.1.58

Warren, B. L., Vialou, V. F., Iñiguez, S. D., Alcantara, L. F., Wright, K. N., Feng, J., … Bolaños-Guzmán, C. A. (2013). Neurobiological Sequelae of Witnessing Stressful Events in Adult Mice. *Biological Psychiatry*, *73*(1), 7–14. http://doi.org/10.1016/j.biopsych.2012.06.006

Waters, S. F., West, T. V, & Mendes, W. B. (2014). Stress contagion: physiological covariation between mothers and infants. *Psychological Science*, *25*(4), 934–42. http://doi.org/10.1177/0956797613518352

Weng, H. Y., Fox, A. S., Hessenthaler, H. C., Stodola, D. E., & Davidson, R. J. (2015). The Role of Compassion in Altruistic Helping and Punishment Behavior. *PLOS ONE*, *10*(12), e0143794. http://doi.org/10.1371/journal.pone.0143794

Westman, M. (2001). Stress and Strain Crossover. *Human Relations*, *54*(6), 717–751. http://doi.org/10.1177/0018726701546002

Wolke, D., Copeland, W. E., Angold, A., & Costello, E. J. (2013). Impact of bullying in childhood on adult health, wealth, crime, and social outcomes. *Psychological Science*, *24*(10), 1958–70. http://doi.org/10.1177/0956797613481608

Yang, Y. C., Boen, C., Gerken, K., Li, T., Schorpp, K., & Harris, K. M. (2016). Social relationships and physiological determinants of longevity across the human life span.

Proceedings of the National Academy of Sciences of the United States of America, *113*(3), 578–83. http://doi.org/10.1073/pnas.1511085112

Zaki, J., & Ochsner, K. (2011). Reintegrating the Study of Accuracy Into Social Cognition Research. *Psychological Inquiry*, *22*, 159–182. http://doi.org/10.1080/1047840X.2011.551743

Zeidner, M., Matthews, G., & Shemesh, D. O. (2015). Cognitive-Social Sources of Wellbeing: Differentiating the Roles of Coping Style, Social Support and Emotional Intelligence. http://doi.org/10.1007/s10902-015-9703-z

APPENDIX C: SUPPLEMENTARY MATERIALS FOR CHAPTER 2

Mean IBI Neither dispositional empathy, $F(2, 122) = 0.46$, $p = 0.634$, cognitive empathy, $F(2, 122) = 0.33$, $p = 0.723$, affective empathy, $F(2, 122) = 0.91$, $p = 0.406$ nor psychopathy of observers, $F(2, 122) = 1.25$, $p = 0.291$ significantly interacted with how their IBI changed in response to viewing the three different video types.

Mean RSA Neither dispositional empathy, $F(2, 122) = 0.39$, $p = 0.675$, cognitive empathy, $F(2, 122) = 0.16$, $p = 0.849$, affective empathy, $F(2, 122) = 1.23$, $p = 0.297$ nor psychopathy of observers, $F(2, 122) = 1.77$, $p = 0.312$ significantly interacted with how their IBI changed in response to viewing the three different video types.

Anxiety ratings Neither dispositional empathy, $F(2, 122) = 1.86$, $p = 0.159$, cognitive empathy, $F(2, 122) = 1.50$, $p = 0.228$, affective empathy, $F(2, 122) = 1.13$, $p = 0.326$ nor psychopathy of observers, $F(2, 122) = 1.63$, $p = 0.200$ significantly interacted with how they rated anxiety levels in the speakers of the three different video types.

Maximum correlation Neither dispositional empathy, $F(2, 122) = 0.24$, $p = 0.790$, cognitive empathy, $F(2, 122) = 0.10$, $p = 0.902$, affective empathy, $F(2, 122) = 0.59$, $p = 0.558$ nor psychopathy of observers, $F(2, 122) = 1.85$, $p = 0.162$ significantly interacted with the maximum correlation achieved between their IBI and that of the speaker, based on the three different video types viewed.

Lag time to reach maximum correlation Neither dispositional empathy, $F(2, 122) = 0.93$, $p = 0.399$, cognitive empathy, $F(2, 122) = 0.60$, $p = 0.548$, affective empathy, $F(2, 122) = 0.98$, $p = 0.379$ nor psychopathy of observers, $F(2, 122) = 1.67$, $p = 0.193$ significantly interacted with the lag time to achieve maximum correlation between their IBI and that of the speaker, based on the three different video types viewed.

APPENDIX D: SUPPLEMENTARY MATERIALS FOR CHAPTER 3

Perceived Likeability Questionnaire (PLQ)

This questionnaire is designed to gauge an individual's likeability. Read the questions carefully and answer them as truthfully as possible.

1. I would be interested in getting to know this person better.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

2. I find this person to be enjoyable.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

3. My personal likes and dislikes are similar to this person's
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

4. I would enjoy being friends with this person.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

5. This person is intelligent.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

6. This person has many friends.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

7. I would enjoy spending time with this person.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

8. I find this person to be annoying.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

9. This person is socially awkward.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

10. This person is an attractive individual.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

11. This person is lazy.
5 – Strongly agree
4 – Somewhat agree
3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

12. This person is interesting.
5 – Strongly agree
4 – Somewhat agree

3 – Neither agree nor disagree
2 – Somewhat disagree
1 – Strongly disagree

Closing survey

Did you feel sorry for the participant who was judged?

a) Definitely yes
b) Somewhat
c) Not really
d) No

Did you feel upset with the other judge?

a) Definitely yes
b) Somewhat
c) Not really
d) No

Did you feel better when administering sound blasts to either participants?

a) Yes, Participant A
b) Yes, Participant B
c) Yes, both
d) No
e) Unsure

Who do you think you gave louder sound blasts to, on average?

a) Participant A
b) Participant B
c) Neither

Have you ever personally been a victim of bullying at any point in your life?

a) Yes
b) Maybe
c) No

If yes, how severe was the bullying?

a) Extremely severe
b) Very severe
c) Moderately severe
d) Hardly severe
e) Not severe
f) I wasn't bullied

How much of an impact has being bullied had on your lift?

a) Extreme impact on my life
b) Significant impact on my life
c) Moderate impact on my life

d) Little impact on my life
e) No impact on my life
f) I wasn't bullied

How believable was this study as a whole?

a) Extremely believable
b) Moderately believable
c) Slight believable
d) Neither believable nor unbelievable
e) Slightly unbelievable
f) Moderately unbelievable
g) Extremely unbelievable

Did you believe that the goal of the study was to measure aspects of friendship?

a) Yes
b) Maybe
c) No

Did you believe that Participant A and B were real?

d) Yes
e) Maybe
f) No