THE EFFECTS OF SHARED ACTIVITY ON DYADIC STRESS RESPONSE

By

BRANDON J. AUER

Bachelor of Science in Psychology

Palm Beach Atlantic University

West Palm Beach, Florida

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Thesis Approved:

Dr. Jennifer Byrd-Craven

Thesis Adviser

Dr. Melanie Page

Dr. Richard Potts

Dr. Mark E. Payton

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Social relationships form the foundation of human societies and the complex nature of social relationships forged between humans distinguish them from other animals. The utilization of unique social tools such as language and nonverbal cues have granted humans extraordinary means of communication and aid in numerous other processes thought to aid in survival and reproduction. It is through social interaction that humans affiliate with one another and powerful bonds are formed that are thought to provide means of protection, caregiving, and assurance during times of distress (Carter & Keverne, 2002). The ability for humans to affiliate and interact with one another is critical for survival and involves several complex processes that interact to allow for the development of relationships that are meaningful throughout the life span (Leckman et al., 2004). Close relationships that are developed through social interaction are known to serve as important sources of social support (Carbery & Buhrmester. 1998; Grabill & Kerns, 2000) and are associated with stress reduction and lower incidence of stress-related psychopathology (Taylor et al., 2000; Taylor, 2006).

While social relationships between humans can often provide both physical and psychological protective advantages compared to humans left to manage stress in isolation, the complex and variable nature of human social relationships may

alsocontribute to stress-related pathology. Indeed, the stresses associated with attempting to anticipate the future actions of individuals who are potential cooperators or competitors can be palpable. Attempting to account for networks of multiple relationships, shifting coalitions, and even deception among social affiliates is no simple task, and as a result, social success can be elusive and challenging (Alexander, 1987, 1990; Axelrod & Hamilton, 1981; Byrne & Corp, 2004; Daly & Wilson, 1988; de Waal, 1982, 2002). Despite the potential drawbacks that intuitively accompany social interactions and relationships between humans, it is reasonable to assume the advantages associated with being a social species outweigh the potential costs as evidenced by the development of numerous brain and cognitive systems over time that appear best suited to successful social navigation. The advanced development of general intelligence in humans, in addition to the development of sophisticated forms of social cognition that facilitate complicated social interactions (e.g., Theory of mind, TOM), indicate that coalitions have played a more important, and more cognitively demanding role for humans compared to similar species over time (Flinn et al., 2005). Why is it then that humans have come to evolve such extraordinary social abilities compared to that of other animals?

Humans are a unique species in sense that they are considered to be an "ecologically dominant" species (Alexander, 1990). Whereas the phenotypes of other species have been continuously influenced through selection by extrinsic forces such as climate, predation, and resource scarcity, the evolution of hominids have been increasingly influenced by interactions within members of the same species. In this sense, Alexander's concept of "ecological dominance" in humans can be best understood to

describe the diminished importance of external selection pressure compared to that provided internally through conspecifics (Flinn et al., 2005). Social interactions between individuals present an avenue by which humans provide their own primary selection pressure and thus, are critical to the understanding of the etiology of the stress response in humans.

Further, human social interactions have not only provided the minimal impetus necessary for internal selection over millions of years, they have ultimately been the driving force behind the modern human phenotype. The human brain's characteristically advanced development distinguishes it from that of other intelligent species, providing an example of the powerful selection forces at work over time. Remarkably, the brain size of hominids have increased by more than 250% in less than 3 million years, with a large proportion of that increase developing during the last 5,000 years (Ruff, Trinkaus, & Holliday, 1997).

The extraordinary cognitive capacities bestowed through the advanced size and organization of the human brain have led to its consideration as a "social tool" whereby numerous psychological adaptations evolve out of a need to navigate social relationships (Alexander, 1971, 1989; Brothers, 1990; Dunbar, 1998; Geary & Huffman, 2002). Due to the ever-changing dynamics found within human social relationships and the capacity for those relationships to change rapidly in response to different social contexts, it has been proposed that interactions between humans provide the necessary catalyst for the evolution of cognitive and brain systems that facilitate increased likelihood of social success (Fodor, 1983; Tooby & Cosmides, 1995). It is clear that successful social interactions, made possible through the internal, conspecific pressures, and the

subsequent selection of advanced brain systems, have largely contributed to our ancestors' ascension to ecological dominance today. Although social interactions played an increasingly important role for our hunter-gatherer ancestors over the centuries, what role, if any, do social relationships and associated stress responses play in the modern world?

While our hominid ancestors likely experienced the same physiological reactions to stressors that modern humans do today, the contexts in which those stressors are encountered have likely changed. In the modern world, humans must interact in multiple and diverse environments on a daily basis, frequently with both same-sex and opposite-sex peers. From the earliest years of life to relatively advanced age, humans must also engage in tasks that require them to compete at times, but also work collaboratively with their peers in order to complete a task. Modern humans are no longer restricted to interacting with only their closest social network; individuals must frequently interact with others that they are unfamiliar in addition to those that they are well acquainted. As individuals are required to work in cooperative or competitive environments with acquaintances or strangers, they are likely to experience both physical and psychological stress. Additionally, the individual experience of stress is expected to change as a person is placed in varying contexts with different demands. Researchers have long been interested in how stress is uniquely experienced from one organism to another and how the individual experience of stress is influenced by different environmental contexts.

Statement of the Problem

Humans are social organisms, and as such, interact with one another on multiple occasions throughout each day. Research literature has clearly demonstrated that human

interactions influence individual physiological responses to stress. Stress response, regulation, and associated emotions can be both adaptive and protective or damaging to the physical and psychological health of a person. Although existing literature supports a relationship between human interaction and the subsequent responses to stress, research examining how the nature of a relationship contributes to such a response, to the best of the author's knowledge, has been very limited in its breadth of exploration.

Purpose

This experiment used a non-invasive, multi-system approach to assess how shared activity between same sex dyads and participant sex influenced stress reactivity in the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system (SNS). Specifically, this experiment assessed reactivity to competitive and cooperative tasks between dyads as measured by changes in the HPA axis and SNS and their biological correlates, cortisol and alpha-amylase.

Hypotheses

During the cooperative task, women were predicted to show greater increases in sAA and CORT from baseline measurements compared to men. Specifically, change scores computed for CORT and sAA concentrations over time (CORT and sAA at time 1 – time 2, CORT and sAA at time 2 – time 3, and CORT and sAA at time 1 – time 3) were expected to be significantly greater in women compared to men. During the competitive task, it is predicted that men will exhibit a stronger stress response than women with greater increases in sAA and CORT from baseline.

CHAPTER II

LITERATURE REVIEW

Stress as Experienced by the Human Organism

Not surprisingly, many social interactions between humans produce psychological stressors that elicit physiological reactions in the body. When the body is met with a threat, it undergoes what is typically referred to as the stress response. The stress response in humans can be conceptualized as a coordinated pattern of changes that take place in the body that are useful in situations in which the person is met with potential damage or loss of resources (Nesse & Young, 2000). In response to threat, the body will undergo immediate changes that typify the "fight or flight" response such as: increased heart rate, increased glucose synthesis to provide energy, redirecting blood from gut and skin to muscles, increased muscle tension for improved strength and endurance, and enhanced blood clotting in preparation for possible tissue damage. The stress response is important to the human organism because failure to adequately mount a response to threat (e.g., a stressor) may ultimately result in death (Cannon, 1929; Cannon, 1932). Stress that is primarily psychological or social will stimulate activity in the body's two main stress systems; the hypothalamic-pituitary-adrenal (HPA) axis, which results in the production of the hormone cortisol, and the sympathetic nervous system (SNS), which stimulates production of the enzyme alpha amylase. When an organism is faced with a

stressor, the sympathetic division of autonomic nervous system (ANS) acts as a first responder, mobilizing the body's resources for immediate action to real or perceived threat. The HPA response to stress, compared to that found in the SNS however, is more delayed and aids in the body's attempt to adapt to both acute and chronic stressors (Huether, 1996; 1998).

Although the term "stress" is commonly used in everyday language, the exact definition of what this word entails remains elusive and has been historically debated. Hans Selye (1956) conceptualized stress as a nonspecific response caused by any number of environmental stressors. Selye posited that while a wide variety of different situations could prompt the stress response, the response itself would ultimately always remain the same. Whenever the body was met with a potentially hazardous threat, it was believed to mobilize itself in a generalized attempt to adapt to that stimulus, highlighting the adaptive nature of the stress response.

As time passed however, Richard Lazarus (1984, 1993) contested this hypothesis, arguing that the interpretation of stressful events is actually more important than the events themselves. According to Lazarus, neither the environment nor the person's response defines stress; Lazarus's cognitively oriented, transactional view of stress emphasized the importance of context in influencing a stress response. Following Lazarus, several investigators have examined how specific characteristics of a stressor, specifically, contexts that are novel (Rose, 1980), unpredictable (Mason, 1968), uncontrollable (Henry & Grim, 1990; Sapolsky, 1993), or threatening, with the potential for harm or loss (Blascovich & Tomaka, 1996; Dienstbier, 1989), would be most likely to

activate the human stress system (Dickerson & Kimeny, 2004). Human social interactions often contain several, if not all, of these characteristics.

With the understanding that social behavior is also biological behavior – humans have inherited certain predispositions through intense selection pressures that are believed to enhance survival and reproduction – examining how social interactions influence or are influenced by biological forces appears to be an appropriate and useful tactic. Hormones that are produced in the body's associated neuroendocrine stress systems appear to be one biological mechanism by which researchers can assess animal and human responses to psychological or physical stress.

Social Environment and Neuroendocrine Regulation

A robust animal and human literature documenting the link between psychosocial factors and neuroendocrine regulation has been developed in recent decades. Fluctuations in two of the main systems involved in the regulation of stress hormones in the human body, the HPA axis, and the SNS, have been consistently linked to stressors of a psychosocial nature. Activity in the HPA axis and SNS systems are primarily assessed due to their central role in the maintenance of homeostatic regulatory processes of the body in response to changing environmental stimuli (McEwen, 1998; McEwen & Stellar, 1993; Sapolsky, 1992; Williams, 1985). Literature has frequently demonstrated that both the HPA axis and the SNS are responsive to external stimuli, particularly through the appraisals or interpretations individuals make concerning stimuli (Williams, 1985). Similar to other social organisms, humans exhibit a marked biological sensitivity to context (Boyce & Ellis, 2004) where their physiologic status is influenced by both physical and social environments (Bovard, 1961, 1985). Indeed, social challenges have

been demonstrated to reliably stimulate the release of the stress hormone cortisol (Dickerson & Kemeny, 2004; Flinn & England, 1997; Gunnar, Bruce, & Donzella, 2000; Kirschbaum & Hellhammer, 1994).

Neuroendocrine Markers of Stress

The use of neuroendocrine markers as a method of gauging human responses to stress has been well established. Salivary cortisol (CORT) has been consistently used as biomarker for HPA axis activity for many years (Kirschbaum & Hellhammer, 1994). Salivary alpha-amylase (sAA) has been used as a marker of activity in the sympathetic adrenal medullar system (SAM) or broadly, a marker of the sympathetic nervous system (SNS) in numerous studies as well (Bosch et al., 1996; Granger et al., 2007; Nater et al., 2005; Rohleder et al., 2006). Stressors that are physical and psychological in nature have been demonstrated to exert an influence on both CORT and sAA in humans. Examination of how CORT and sAA interact to permit, stimulate, or suppress stress responses in humans is of particular interest because dysregulation of the SNS and HPA axis stress systems and their corresponding biomarkers (e. g., sAA and CORT) are thought to have numerous health implications.

Studies have found that persons with low HPA axis activation and high SNS activation have to the lowest risk for the development of internalizing problems (Bauer et al, 2002; El-Sheikh et al., 2008) and that children with HPA and SNS asymmetry are least likely to have internalizing or externalizing adjustment problems compared to persons who had high or low activity in both systems (El-Sheikh et al., 2008). Low activity in both systems is associated with externalizing disorders (Gordis, Granger, Susman, & Trickett, 2006). There have also been numerous health consequences

associated with HPA and SNS dysregulation, namely, individuals with dysregulated stress system are more susceptible to the development of various illnesses, coronary heart disease, and other chronic inflammatory diseases such as asthma (Miller et al., 2009).

Traditionally, researchers have primarily focused on how psychosocial stressors influence activity in the HPA system alone through assessment of cortisol, establishing a firm base for the use of a newer biomarker such as alpha-amylase that is thought to reflect activity of the SNS.

Hypothalamic-Pituitary-Adrenal Axis and Cortisol

The HPA axis in humans is known to develop within the first several years of life and has been shown to be highly sensitive to early, adverse caregiving experiences (de Weerth, Zijl, & Buitelaar, 2003; Flinn, 2006; Fries, Shirtcliff, & Pollak, 2008; Watamura et al., 2004). The stress hormone cortisol is produced in the HPA system through a complex interaction between the external and internal environments of an individual. First, the thalamus and the frontal lobes (e.g., the frontal cortex) integrate sensory information and appraise the significance or meaning of environmental stimuli. The cognitive appraisals can then lead to the generation of emotional responses via extensive connections from the prefrontal cortex to the limbic system (e.g., the amygdala and hippocampus). The limbic structures, which connect to the hypothalamus, serve as a primary pathway for activating the HPA axis (see Feldman, Conforti, & Weidenfeld, 1995, or Lovallo, 1997, for reviews on central nervous system inputs to the HPA system). The HPA axis is then activated by the release of corticotrophin releasing hormones (CRH) from the hypothalamus, which further stimulates the secretion of adrenocorticotropic hormone (ACTH) in the anterior pituitary. Following the release of

ACTH, the adrenal cortex is stimulated to release cortisol into the blood stream (for review, see Lovallo & Thomas, 2000; Sapolsky, Romero, & Munck, 2000).

Environmental stimuli that are interpreted as posing a physical or psychological threat, are challenging, and are novel will stimulate the HPA axis to release glucocorticoids (Nesse & Young, 2000). The release of glucocorticoids in primates primarily takes the form of cortisol (Gunnar et al., 1988). Glucocorticoids that are released in the body assist in a host of biological processes such as functioning of the cardiovascular and immune systems, regulation of emotion, cognition, and energy release as well (Diorio, Viau, & Meaney, 1993; Sapolsky, Romero, & Munck, 2000; Takahashi et al., 2004). Activity in the HPA system in response to stress is controlled by means of a negative feedback loop between glucocorticoids and multiple brain regions (Dallman, 1993). The hormonal changes brought about through the release of glucocorticoids allow an organism to appropriately respond to stress via adaptation and assist in effective coping. Though acute elevation of cortisol may prove adaptive for an organism, prolonged and chronic periods of cortisol elevation are thought to lead to numerous health concerns including psychopathology (Goodyer et al., 2001; Gunnar & Vazquez, 2001; Heim et al., 1997; Sapolsky, 2000).

Research that documents associations between specific stressors and cortisol responses can contribute to the understanding of link between cognitive and affective responses associated with specific stressful circumstances, the neural substrates of these responses, and activation of the HPA system.

The HPA axis is critical to normal physiological functioning and is heavily involved in the regulation of other systems. Cortisol influences metabolic functioning

through the mobilization of energy for the body. This process is achieved through elevating blood glucose, which results in the release of energy reserves that promote metabolic functioning. Cortisol also serves as a critical regulator of other physiological systems; for instance, cortisol possesses the ability to inhibit several aspects of immune system functioning. Cortisol has natural anti-inflammatory properties where proteins that typically contribute to inflammatory processes are inhibited. In addition to its anti-inflammatory properties, cortisol also has permissive effects, which allow other physiological systems to function properly (Sapolsky et al., 2000).

Furthermore, the HPA axis is associated with cognitive and affective processes that influence overall health and disease. Heightened HPA activity is closely related to depressive symptomology (Brown & Suppes, 1998; Heim & Nemeroff, 1999). Chronic cortisol release has also been demonstrated to exert an influence on various aspects of memory such as enhanced memory for emotional material (Buchanan & Lovallo, 2001), impaired declarative memory in healthy adults (Kirschbaum et al., 1996), and impaired declarative memory in elderly subjects as well (Lupien et al., 1997). It is important to note that although chronic cortisol release has been implicated in various pathologies, short-term cortisol release plays an role in maintaining health by aiding an organism's adaptation to various stressors, thus, making it an indispensable commodity.

Over the past half-century, numerous studies have specifically focused on the effects of psychological stressors on cortisol activation. Salivary cortisol has been proven to be a valid and reliable biomarker of activity in the hypothalamic-pituitary-adrenal (HPA) axis and its use is widely accepted and frequently implemented in psychoneuroendocrinology (Dickerson & Kemeny, 2004). Determination of salivary

cortisol presents several advantages for research that is both clinical and basic in nature; it is cost-effective, non-invasive, and relatively convenient to sample (Kirschbaum & Hellhammer, 1994). The critical questions concerning the specific conditions that induce cortisol responses in the HPA axis have generated numerous hypotheses over the years (Dickerson & Kemeny, 2004).

Although further research is required in order to determine what psychological stressors with specific characteristics preferentially elicit cortisol responses in humans, research with animals support the premise that there could be stressor-specific pathways to cortisol activation (Dickerson & Kemeny, 2004). Conspecific contact between members of the same species can be supportive and protective (reducing activation of the HPA system) or damaging (elevating activation in the HPA system). Studies of both rodents and non-human primates have shown that contact with other individuals of the same species influences successful social, psychological, and physiologic development and reduces physiological arousal in the presence of stressors (Bovard, 1961; Cassel, 1976; Davitz & Mason, 1958; Hennessey, 1984; Staton et al., 1985; Clarkson et al., 1987). Animal research has also demonstrated both positive and negative effects of social environment on the stress response (Clarkson et al., 1987; Levine, 1993). Furthermore, studies exposing animals to distinct types of physical, or systemic, stressors (e.g., heat, shock) have been shown to induce different effects in the HPA system (Weiner, 1992). In the animal literature, distinctive physiological correlates for different stress-relevant behavioral patterns in animals have also been found (e.g., fighting, fleeing, submitting; Weiner, 1992).

Research examining how psychological characteristics of stressors influence HPA activity in humans has provided mixed results. The wealth of studies investigating the relationship between psychological stress and cortisol activation have reliably shown it to be responsive to stressors that are perceived to be uncontrollable and present a type of socio-evaluative threat. More importantly, the data clearly indicate that HPA reactivity is not responsive to all types of stressors (Dickerson & Kemeny, 2004), highlighting the importance of taking context into account. Despite some inconsistencies, considerable evidence has been provided that demonstrates the link between psychological stress and cortisol activation in humans. For instance, laboratory tasks such as public speaking or mental arithmetic have been found to increase cortisol levels (e. g., Kirschbaum, Pirke, & Hellhammer, 1993) in subjects. In addition, there is evidence for negative associations between relative social status and other important physiologic processes (Baker et al., 1988; Rose & Marmont, 1981; Moller et al., 1991). There have been links between adrenocorticol activity and adaptive coping (Essex et al., 2002), competition stress (Gladue et al., 1989; Hasegawa et al., 2008; Kivlighan & Granger, 2006), dominance (Wirth et al., 2006), brief social separation and attachment anxiety (Hennessy, 1996; Quirin et al., 2008), co-rumination in friendships (Byrd-Craven et al., 2008), social support (Heinrichs et al., 2003), as well social rejection and achievement stress (Stroud et al., 2002). Due to the extensive literature undergirding the link between environmental stressors and the release of cortisol in the human body as a direct response, the use of CORT in this study to gauge reactivity to social stress in dyads engaging in cooperative and competitive activities appears to be well supported.

The Sympathetic Nervous System and Alpha-Amylase

While salivary cortisol has been the predominant biological marker used in human stress research in the past, the salivary enzyme alpha amylase has recently grown in popularity as a novel method of assessing stress induced activity in the sympathetic nervous system (SNS). Salivary alpha amylase (sAA) is secreted from the salivary glands in response to sympathetic stimuli and serves as one of several critical protein components in saliva. Furthermore, sAA plays a key role in the enzymatic digestion of carbohydrates (Baum, 1993), and has been demonstrated to support mucosal immunity in the oral cavity, where it is shown to inhibit the growth of bacteria (Scannapieco et al., 1993). Substantial evidence supporting the link between sAA and sympathetic activity has been provided through pharmacological studies (van Stegeren et al., 2006; Ehlert et al., 2006). Such studies have contributed to the assumption of sAA as a valid marker of the sympathetic activity.

Alpha amylase as a biomarker is relatively easy to sample and is cost-effective when assessed in human saliva. The potential significance of sAA as a marker of adrenergic activity is of substantial importance to human stress research because it affords investigators the ability to examine activity between the two major neuroendocrine stress systems (i.e., SNS and HPA-axis) in parallel with salivary samples (Chatterton et al., 1996). The ability to gauge activity of both major stress systems within a single saliva sample that is noninvasive and requires no elaborate technical instrumentation to collect is particularly attractive to the potential researcher. Due to its numerous advantages, the use of sAA as a stress biomarker is expected to continue in the future (Rohleder & Nater, 2008).

Since the first proposal of sAA as a biological marker of SNS activity by Chatterton et al. in 1996, several studies have supported the utility of the enzyme in this capacity. Numerous studies have documented the relationship between sAA and reactivity to social stress in the SNS (Bosch et al., 2005; Byrd-Craven et al., 2011; Chatterton et al., 1996; Gordis, Granger, Susman, & Trickett, 2006; Nater et al., 2005, 2006; Noto, Sato, Kudo, Kurata, & Hirota, 2005; Rohleder, Nater, Wolf, Ehlert, & Kirschbaum, 2004; Rohleder, Wolf, Maldonado, & Kirschbaum, 2006; Skosnik, Chatterton, Swisher, & Park, 2000; Takai et al., 2004) as well as reactivity to stress of a physical nature (Chatterton et al., 1999; Gilman et al., 1979; Li & Gleeson, 2004; Walsh et al., 1999). Additional evidence linking psychosocial stress to sAA activity in the SNS has also been provided (for a recent review see Nater and Rohleder, 2009). Just as the evidence linking CORT activity in the HPA axis to psychosocial stress has been validated in experimental research, the data presented on sAA activity in the SNS also suggests sAA to be a valid biomarker of psychological stress.

Coordination of Alpha-Amylase and Cortisol

Previous research has largely focused its attention on only one biological stress system at a time (e.g., the HPA axis and cortisol). The conclusions drawn from such data may be problematic due to the fact that the HPA and SNS systems have been shown to display different response patterns and interrelations to one another (Frankenaeuser, 1982). Interpretation is further complicated by research demonstrating the capacity for activity in one stress system to be influenced by the other (Boyce & Ellis, 2005; Sapolsky et al., 2000). Previous studies that have focused on only one stress system at a time have been potentially constrained by neglecting possible interactions between stress systems to

predict physiological correlates of social stress. As a result, Bauer and colleagues (2002) have proposed an "additive" model where the HPA and SNS systems are thought to augment each other, and concurrent assessment of both stress systems are believed to provide better predictive value than examination of any one stress system alone.

Few published studies have specifically examined the social contexts under which the HPA and SNS stress system interact. Recent research has found interactions between salivary cortisol (CORT) and alpha-amylase (sAA) in response to the Trier Social Stress Test (TSST). Gordis and colleagues (2006) found interactions between CORT and sAA to be associated with externalizing symptoms in adolescents. In addition, this study found asymmetry between the two stress systems (high HPA reactivity and low SNS reactivity) to be associated with lower levels of aggression, while symmetry between the two systems (low HPA and SNS reactivity) to be associated with higher levels of aggression in adolescents. Underscoring Bauer and colleagues' (2002) additive model, this study determined that examining the combined effect of each stress system explained more variance in aggressive behavior in adolescents than each system individually.

Coordinated activation of the HPA axis and SNS has also been associated with effective coping strategies in children placed in a violent family context (Cleary, Rigterink, & Katz, in press) while increased levels of sAA found in adolescents in response to peer rejection has been associated with internalizing problems (Stroud et al., 2009). Finally, Byrd-Craven, Auer, & Granger (2011) found dual stress system activation in response to negative affect in co-ruminating female friendship dyads.

The current collection of research taken as whole, suggests that the HPA axis and SNS stress systems both react to psychosocial stressors and interact with one another to produce a physiological response to threat that can be either protective or maladaptive. The development of a non-invasive measure of SNS reactivity (e.g., sAA) has only been acquired recently. As a result, there remain several lingering questions surrounding the unique social contexts that differentially influence individual neuroendocrine responses to stress. This study seeks to address some of those questions, specifically, how the sex of the dyad and nature of a social task (i.e., competitive or cooperative) uniquely influence activity in the HPA and SNS systems.

Sex Differences in Stress Response

Traditionally, it was widely assumed that both men and women experienced the effects of stress in the same way. As a result, women were often excluded from analyses assessing stress reactivity in humans. Understandably, this exclusion left a large gap in the stress literature and has only recently been addressed.

Taylor and colleagues (2000, 2006) hypothesized that women are more likely to affiliate under stressful conditions compared to men who exhibit a more traditional fight-or-flight response. The tendency to tend-and-befriend, whereby females form small networks of interpersonal relationships as protective coalitions, is thought to increase the chances of survival of both the mother and her offspring when in the presence of threat or danger. The social networks that are created and maintained assist with protection of the female and her offspring and aid nurturing activities. When faced with a threat, Taylor and colleagues argue that it would not be beneficial or even practical for a women to fight or flee from threat; it would place relatively defenseless offspring in danger. It would be

more beneficial to the mother and her offspring to join a social group that can provide both protection from danger and assist in caregiving responsibilities. As a result of this reality, it is believed that neuroendocrine processes thought to enhance this tending-and-befriending process have evolved over time.

Despite gaps in the literature, several studies assessing responses to stress in humans have found considerable differences between sexes. Both men and women produce the posterior pituitary hormone oxytocin which is associated with parasympathetic functioning and thought to have a counter-regulatory effect on fight-or-flight responses to stress (Dreifuss et al., 1992; Sawchenko & Swanson, 1982; Swanson & Sawchenko, 1980). Oxytocin has been found to enhance sedation and relaxation, reduce fearfulness, and decrease sympathetic reactivity in animal studies (Uvnas-Moberg, 1997). In women, oxytocin release in response to stress is greater than that of men (Jezzova et al., 1996) and has been found to facilitate increased affiliation (Taylor, 2006).

In addition, androgens are known to inhibit oxytocin release under stressful conditions (Jezova et al., 1996) and the effects of oxytocin are significantly regulated by the presence of estrogen (McCarthy, 1995). These findings taken together suggest the men may be more prone to the prototypical fight-or-flight response compared to women; men produce testosterone, an androgen that ultimately restricts the release of oxytocin and its calming effects on sympathetic functioning.

The release of oxytocin in humans is also known to inhibit the release of glucocorticoids, which are associated with anxiolytic properties that reduce symptoms of anxiety (Chiodera et al., 1991). The effects of estrogen-enhanced release of oxytocin likely impact activity in the HPA axis as well. As the previously mentioned research

might suggest, men have typically been found to exhibit greater overall cortisol levels compared to women in the presence of stressors (Dickerson & Kemeny, 2004).

One of the strongest known effects of estrogen involves its significant influence on oxytocin release in humans (McCarthy, 1995). The oxytocin effect in women has been documented to be highly potent and the duration of such effects are known to be long lasting (Uvnas-Moberg, 1997). Women who are lactating have been documented to have lower levels of sympathetic arousal (Wiesenfeld et al., 1985) and have also been found to suppress HPA responses to stress (Altemus et al., 1995). Taylor et al. (2000, 2006) suggest that women may be particularly predisposed to affiliate under stressful conditions compared to men and previous literature has supported this phenomenon as one of the most robust gender differences in adult human behavior (Belle, 1987). Exposure to noise has led to decreased fondness between male participants but resulted in increased feelings of liking between female participants (Bull et al., 1972). Men have also been shown to prefer less social interaction compared to women when presented with heat and noise stressors (Bell & Barnard, 1977).

Women have been further demonstrated to harbor a strong tendency to affiliate with those of the same sex (Schachter, 1959). Women may be more likely to affiliate under stressful laboratory conditions then male participants, but only under conditions where others are more similar, particularly when they are the same sex (Taylor et al., 2000).

Men also have been found to invest in several social networks, but unlike females who tend to emphasize the importance of bonding in relationships, men tend to gravitate to relationships that are more organized around well-defined purposes and emphasize

hierarchies of status and power (Baumeister & Sommer, 1997; Spain, 1992). Furthermore, men have been found to engage in larger social groups than those of women who enter into smaller social groupings that partake in more affiliative behaviors (Baumeister & Summer, 1997).

The same neuroendocrine mechanisms thought to mediate the attachment-caregiver system are also found to have similar influences on close friendships (Panksepp, 1998). Notably, friendship interactions in the presence of stressors have been found to down-regulate sympathetic and neuroendocrine reactivity to stress and assist in subsequent recovery from those stressors (Christenfeld et al., 1997; Fontana et al., 1999; Glynn, Christenfeld, & Gerin, 1999; Thorsteinsson, James, & Gregg, 1998).

Women have reliably demonstrated higher personal ratings of emotional material compared to men, and have demonstrated better memory performance involving emotional information as well (Bradley et al., 2001; Cahill & van Stegeren, 2003; Canli et al., 2002; van Stegeren et al., 1998). Research has also demonstrated differences between sexes on baseline cardiovascular measures including blood pressure and heart rate (Saab et al., 1989; Suarez et al., 2004) as well as neuroendocrine response to acute stress that is psychosocial in nature (Kudielka et al., 1998; Kuhlmann & Wolf, 2005; Stark et al., 2006; Wolf et al., 2001). Numerous studies have found greater salivary cortisol responses in men compared to women in reaction to stressors (Kirschbaum et al., 1999; Kudielka and Kirschbaum, 2005) although sex differences fail to account for a significant amount of variability in cortisol responses for children (for review see Dickerson & Kemeny, 2004).

To date, very few studies have assessed the role sex plays in influencing sAA levels in response to stress and those that have been conducted have provided mixed results (Kivlighan & Granger, 2006; Nater et al., 2006; Takai et al., 2007). In previous studies, men were found to have higher sAA than women but in those cases it was determined to be statistically non-significant (Kivlighan & Granger, 2006) or trending towards significance (van Stegeren et al., 2006). Recently, van Stegeren et al. (2008) found significantly higher baseline levels of sAA in men compared to women during tasks requiring them to rate aversive pictures and complete a cold pressure stress (CPS) task. Although this finding contrasted with previous research assessing the diurnal profile of sAA in groups of men and women throughout a normal day (Nater et al., 2007), the discrepancy may be attributable to the anticipatory nature of the study where participants were aware that they would be emotionally challenged. It is speculated that this aspect of the stressor may influence SNS and sAA levels in men more than women (van Stegeren et al., 2008).

It is important to note that just as men have been disproportionately represented in the literature examining responses to stressors, women have been overrepresented in those studies assessing affiliation under conditions of stress. Because both sexes have received inadequate representation in either field, it is difficult to interpret patterns of response for either males or females due to a lack of data (Taylor et al., 2000).

Further research investigating the contexts under which sex differences influence sAA reactivity to stressors is required to develop a more complete understanding of how individuals respond to stressful tasks. Existing literature suggests that genuine differences

between sexes may exist and research investigating such an effect would prove to be a worthwhile venture for the field of psychoneuroendocrinology.

Sex Differences in Competition and Cooperation

Compared to young girls, young boys appear to make greater efforts to establish and maintain dominance in social hierarchies. In regard to competition specifically, boys' games tend to be more competitive than those typically played by girls. Around the time of middle childhood, male competition changes such that competitive groups become larger in size and begin to more clearly organize around more structured games. Interestingly, most competition between boys takes place between groups while the majority of competition among girls takes place within groups. Indeed, girls have been found to engage in more cooperative play styles and interactions while boys have been found to engage in play that is more competitively oriented (Maccoby, 1998).

CHAPTER III

METHOD

Participants

A total of 90 undergraduate students were recruited from the psychology subject pool at Oklahoma State University for participation in the study. Out of the 90 recruited participants recruited, 17 participants were excluded from analysis due to noncompliance with specified instructions to avoid confounding. A total of 10 pre-task CORT samples and 20 post-task CORT samples were unable to be assayed due to insufficient quantity of saliva for analysis. In addition, 18 pre-task sAA samples and 41 post-task sAA samples were unable to be assayed due to an insufficient quantity of saliva. A total of 73 participants were included in the final analysis. Participants were 53% men and 37% were women. Ages in the sample ranged from 18 to 31 years old (M = 19.11, SD = 1.73). 81.1% of participants were Caucasian, 10% were African American, 3.3% were Asian American, 2.2% were Native American, 2.2% were Hispanic, and 1.1% were described as "other." Participants were offered the opportunity to participate in the study through the SONA recruiting system.

Procedure

After arriving to the laboratory, the study was briefly described to participants and participants were asked to read and sign a consent form following any questions. After

consent, participants were asked to complete a series of questionnaires concerning their friendships, personality, family background, overall health, use of medications, recent activities, and other demographical knowledge of interest to the experimenter (see Appendix A). In addition, subjects' perception of the video-game task was assessed prior to their participation in the study (e.g., is the task achievement-oriented vs. social-oriented?). Prior to participation in the study, subjects were randomly assigned to one of two possible experimental conditions by coin flip. Following the completion of questionnaires, participants were instructed to 1) compete or 2) cooperate with a confederate on a task.

Participants completed both the questionnaires and the experimental task in the same session. Each participant and their assigned partner played Bomberman® Ultra on the PlayStation®3, a strategy-based video game that required them to either work together in a cooperative fashion or directly compete against one another. Each dyad engaged in the assigned task for 20 minutes to capture CORT and sAA at their associated peak. If consent was provided, participants and their partner were video-recorded throughout the duration of the experimental task. Recorded interactions between dyads will be used for future behavioral coding (see appendix A). Saliva for cortisol and sAA levels were collected immediately before beginning the assigned task (Sample 1), immediately following the task (Sample 2), and twenty minutes following the completion of the task (Sample 3). Table I provides the timeline of the sample collections related to the timing of tasks. Collection of saliva at the stated intervals was consistent with recommendations from previous work utilizing CORT and sAA (Granger et al., 2007). Dyads were separated post-task until the third sample was collected. This was done in

order to prevent social interaction that may confound results. Saliva vials were labeled and stored for later analysis

Table 1

Timeline of Tasks and Sample Collections

Sample Number	Description	Name of Sample
1	CORT and sAA levels within 5 minutes of beginning the task	CORT@T1; sAA@T1
2	CORT and sAA levels immediately following 20 minute task	CORT@T2; sAA@T2
3	CORT and sAA levels 20 minutes after completion of 20 minute task	CORT@T3; sAA@T3

Determination of Salivary Analytes

In biobehavioral research, the collection of saliva has received considerable attention due to its perceived ability to be quickly and easily administered in a non-invasive manner (Kirschbaum, Read, & Hellhammer, 1993). Participants were instructed to avoid potential confounding influences in HPA and SNS activity at least 1 hour prior to participation in the study.

Among the activities and substances known to influence sAA and SNS reactivity are: tobacco use, intake of alcohol, use of adrenergic agonists and antagonists found in certain medications, ingestion of caffeine and food, as well as physical exercise with greater reactivity found in exertion that is more strenuous. Other influences known to potentially impact sAA and SNS activity are age and the presence of somatic/psychiatric

disease. For sAA, current data do not support sex differences in basal or acute amylase responses but pregnancy does appear to attenuate stress responses (for review see Rohleder & Nater, 2009). Factors that are known to influence cortisol and HPA activity include tobacco use, physical exercise, genetic variables, as well as the sex of the participant (for review see Kirschbaum & Hellhammer, 1994). Other influences that have been found to impact cortisol and HPA activity include the use of stimulants (Schwartz et al., 1998), posture of the participant prior to collecting saliva (Hennig et al., 2000), time of day when saliva is collected, and relative health of participant, among other factors (Kirschbaum & Hellhammer, 1994). Males have been consistently found to have stronger cortisol reactivity to psychological stress when compared to females even when only anticipating a stressor with no subsequent exposure.

Participants were instructed to avoid all potential confounds, within reason, at least one hour prior to participation in the study and completed a questionnaire concerning their activities prior to arrival (e.g., sleep, diet, activity level, etc.). Six participants reported consuming caffeine within one hour of participation in the experiment and were also excluded. Five participants reported having consumed a "large meal" within one hour of participation of the study and were excluded from analysis. In addition, participants completed a questionnaire that rates health on a 1-10 scale. The questionnaire assessed symptoms of impending illness (e.g., fever, runny nose) that may have influenced HPA and SNS activity and solicited information pertaining to the current use of any medications by the participant. Four participants reported having a fever during the experiment and were excluded from the analysis. No participants in this

analysis reported using medications such as corticosteroids that would interfere with the accuracy of assays.

Measures

Salivary Cortisol and Alpha-Amylase

All saliva samples were assayed for both salivary α-amylase (sAA) and cortisol. Saliva was collected by instructing participants to saturate 1 x 4 CM absorbent swabs in their mouths for 1-2 minutes. The swabs containing participant saliva were stored at -20ºC. In accordance with Granger and colleagues (2007) recommendation, saliva samples were assayed for sAA (kinetic reaction) and cortisol (enzyme immunoassay) using commercially available reagents (Salimetrics, State College, PA) without modification to the manufacturer's suggested protocols. CORT concentrations in salvia are expressed in micrograms per deciliter (ug/dL) and sAA concentrations are expressed in units of enzymatic activity per milliliter (U/mL). Assays had average intra- and inter-assay coefficients of variation less than 5% 15% respectively. The mean intra-assay coefficient is a measure of the average variability for each assay from the same sample. The mean inter-assay coefficient of variation is a measure of the average variation from the controls provided in the assay kits. It represents the average difference from expected values for the Control samples.

CHAPTER IV

RESULTS

Analytical Strategy

Examination of Q-Q plots to test for the assumption of normality revealed normal distributions for CORT and sAA at all time intervals except sAA collected at time 1 ("sAA@T1"). The Shapiro-Wilk test confirmed the violation of normality, for sAA at time 1, $p < .05$. The assumption of normality was met for all other measurements. Square-root transformations were conducted in order to normalize the distribution for sAA values at time 1 (see Gordis et al., 2006). In addition, several samples were identified as outliers using box and whisker plots. Outliers constituted 3 pre-task CORT samples, 5 pre-task sAA samples, 9 post-task CORT samples, and 4 post-task sAA samples. Outliers were not included in statistical analysis.

Pre-task and Post-task CORT and sAA

Table 2

Mean +/- SD of Pre-task and Post-task CORT and sAA Concentration

	CORT	sAA
Time 1	.21 (.13)	50.23 (45.61)
Time 2	.17(.09)	54.35 (48.44)
Time 3	.14(.07)	58.44(52.22)

CORT Change from Time 1 to Time 2:

A two-way ANOVA was conducted to examine the effect of sex and condition on change in CORT concentration from baseline (Time 1) to immediately following completion of the task (Time 2). The dependent variable, CORT change from time 1 to time 2, was normally distributed as determined by the Shapiro-Wilk test. There was homogeneity of variance between groups as assessed by Levene's test for equality of error variances. Main effect analysis showed no significant effect for sex, $F(1,74) = .04$, $p = .85$, $\eta p^2 = .00$, or condition, $F(1,74) = 1.98$, $p = .16$, $\eta p^2 = .03$. As shown in *Figure 1*, there was a significant interaction between sex and condition, $F(1,74) = 5.88$, $p = .02$, $\eta p^2 = .08$. To further probe the interaction effect, a linear regression was conducted with CORT change from time 1 to time 2 as the dependent variable and sex as the selection variable. Condition was determined to be a significant predictor of change in CORT from Time 1 to Time 2 for females, B = .37, $t(225) = 2.22$, $p = .03$, but not for males, $p > .05$. Condition also explained a significant proportion of variance in CORT change, $R^2 = .14$, $F(1, 31) = 4.95$, $p < .05$.

Table 3

Mean +/- SD Cortisol Change for Men and Women Time 1 to Time 2

	Competitive		Cooperative	
Sex	Mean	SD	Mean	SD
Male	- .06	.09	- .04	.12
Female	.01	.11	- .10	.17

Note. The mean score reflects change in cortisol concentration from baseline to immediately following the task.

Figure 1. Change in CORT from time 1 to time 2 as a function of type of activity and sex of participant.

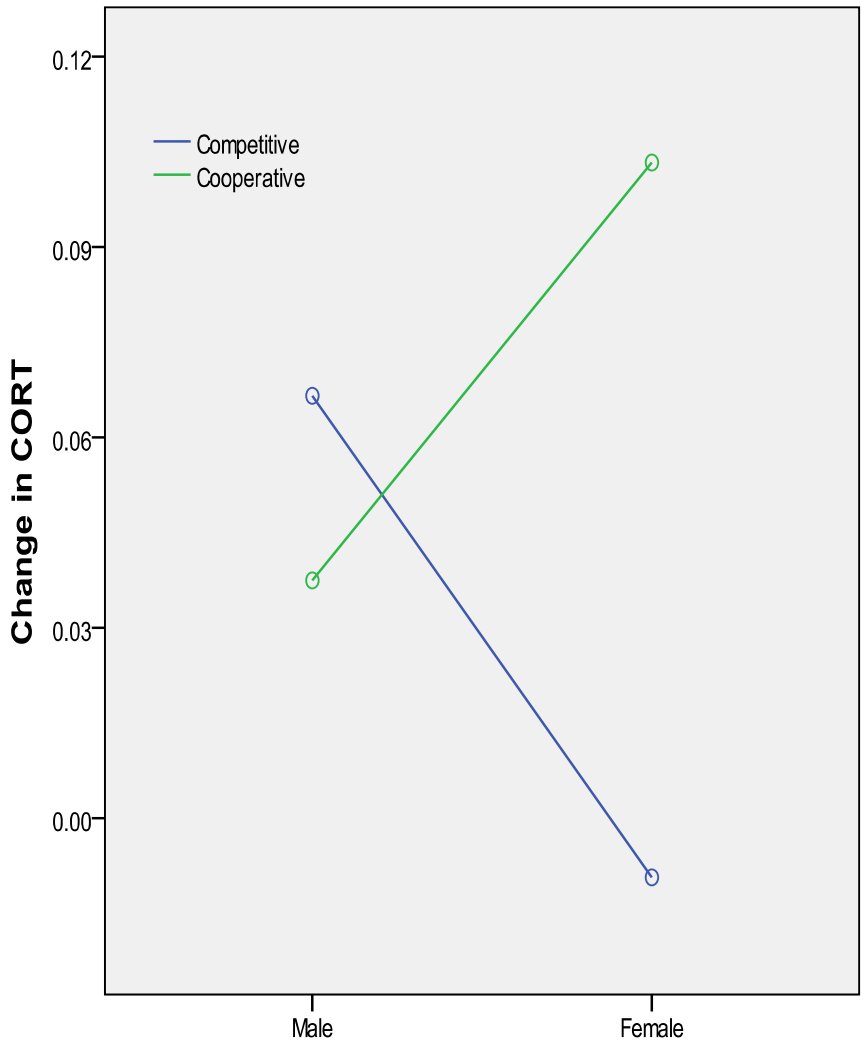

Figure 1. Change in CORT concentration pre-task (time 1) to post-task (time 2) for men and women in engaging in cooperative or competitive tasks. Women differed significantly between tasks with greater decreases in CORT within the cooperative condition than the competitive condition. CORT did not significantly change for men between tasks.

CORT Change from Time 2 to Time 3:

A two-way ANOVA was conducted to examine the effect of sex and condition on change in CORT concentration from immediately following completion of the task (Time 2) to 20 minutes post-task (Time 3). The dependent variable, CORT change from time 2 to time 3, was normally distributed as determined by the Shapiro-Wilk test. The assumption of homogeneity of variance between groups as assessed by Levene's test for equality of error variances was violated for CORT change from time 2 to time 3, $p < .05$. Main effect analysis showed no significant effect for sex, $F(1,80) = .32$, $p = .57$, $\eta p^2 = .00$. There was a significant main effect of condition, $F(1,80) = 4.13$, $p = .04$, $\eta p^2 = .05$, where the decrease in CORT concentration was greater in the competitive condition compared to the cooperative condition. There was not a significant interaction between sex and condition, $F(1,80) = .66$, $p = .42$, $\eta p^2 = .01$.

Table 4

Mean +/- SD Cortisol Change for Men and Women Time 2 to Time 3

	Competitive		Cooperative	
Sex	Mean	SD	Mean	SD
Male	- .06	.04	- .03	.06
Female	- .09	.17	- .02	.11

Note. The mean score reflects change in cortisol concentration from immediately following the task to 20 minutes post-task.

CORT Change from Time 1 to Time 3:

A two-way ANOVA was conducted to examine the effect of sex and condition on change in CORT concentration from baseline (Time 1) to 20 minutes post-task (Time 3).

The dependent variable, CORT change from time 1 to time 3, was normally distributed as determined by the Shapiro-Wilk test. There was homogeneity of variance between groups as assessed by Levene's test for equality of error variances. Main effect analysis showed no significant effect for sex, $F(1,74) = .17$, $p = .67$, $\eta p^2 = .00$, or condition, $F(1,74) = .06$, $p = .80$, $\eta p^2 = .00$. There was no significant interaction between sex and condition, $F(1,74) = 2.51$, $p = .11$, $\eta p^2 = .03$.

Table 5

Mean +/- SD Cortisol Change for Men and Women Time 1 to Time 3

	Competitive		Cooperative	
Sex	Mean	SD	Mean	SD
Male	- .12	.09	- .06	.12
Female	- .08	.12	- .13	.20

Note. The mean score reflects change in cortisol concentration from baseline to 20 minutes post-task.

sAA Change from Time 1 to Time 2:

A two-way ANOVA was conducted to examine the effect of sex and condition on change in sAA concentration from baseline (Time 1) to immediately following completion of the task (Time 2). The dependent variable, sAA change from time 1 to time 2, was normally distributed as determined by the Shapiro-Wilk test. There was homogeneity of variance between groups as assessed by Levene's test for equality of error variances. Main effect analysis showed no significant effect for sex, $F(1,70) = .03$, $p = .84$, $\eta p^2 = .00$, or condition, $F(1,70) = 1.10$, $p = .29$, $\eta p^2 = .02$. There was no significant interaction between sex and condition, $F(1,70) = .52$, $p = .47$, $\eta p^2 = .01$.

Table 6

Mean +/- SD Alpha-Amylase Change for Men and Women Time 1 to Time 2

	Competitive		Cooperative	
Sex	Mean	SD	Mean	SD
Male	7.46	52.73	3.43	47.30
Female	18.61	72.47	-3.03	19.68

Note. The mean score reflects change in alpha-amylase concentration from baseline to immediately after task.

sAA Change from Time 2 to Time 3:

A two-way ANOVA was conducted to examine the effect of sex and condition on change in sAA concentration from immediately following completion of the task (Time 2) to 20 minutes post-task (Time 3). The dependent variable, sAA change from time 2 to time 3, was normally distributed as determined by the Shapiro-Wilk test. There was homogeneity of variance between groups as assessed by Levene's test for equality of error variances. Main effect analysis showed no significant effect for sex, $F(1,65) = .08$, $p = .76$, $\eta p^2 = .00$, or condition, $F(1,65) = .14$, $p = .70$, $\eta p^2 = .00$. There was no significant interaction between sex and condition, $F(1,65) = .08$, $p = .77$, $\eta p^2 = .00$.

Table 7

Mean +/- SD Alpha-Amylase Change for Men and Women Time 2 to Time 3

	Competitive		Cooperative	
Sex	Mean	SD	Mean	SD
Male	1.78	35.21	.98	40.45
Female	1.73	32.99	-4.11	25.89

Note. The mean score reflects change in alpha-amylase concentration from immediately after task to 20 minutes post-task.

sAA Change from Time 1 to Time 3:

A two-way ANOVA was conducted to examine the effect of sex and condition on change in sAA concentration from pre-task (Time 1) to 20 minutes post-task (Time 3). The dependent variable, sAA change from time 1 to time 3, was normally distributed as determined by the Shapiro-Wilk test. There was homogeneity of variance between groups as assessed by Levene's test for equality of error variances. Main effect analysis showed no significant effect for sex, $F(1,64) = .17$, $p = .67$, $\eta p^2 = .00$, or condition, $F(1,64) = 1.66$, $p = .20$, $\eta p^2 = .03$. There was no significant interaction between sex and condition, $F(1,64) = .15$, $p = .69$, $\eta p^2 = .00$.

Table 8

Mean +/- SD Alpha-Amylase Change for Men and Women Time 1 to Time 3

	Competitive		Cooperative	
Sex	Mean	SD	Mean	SD
Male	8.86	44.49	-4.01	60.01
Female	20.35	92.86	-3.62	22.12

Note. The mean score reflects change in alpha-amylase concentration from baseline to 20 minutes post-task.

CHAPTER V

DISCUSSION

This study examined how cooperative and competitive activities uniquely influence activity in the HPA and SNS systems between sexes as measured by CORT and sAA. The present study did not find any significant effect of sex or condition on SNS activity and sAA. Alpha-amylase activity is thought to represent activity in the sympathetic nervous system as part of the "fight-or-flight" response while CORT is thought to represent activity in the HPA axis. Non-significant increases in sAA concentration and steadily declining CORT concentrations from baseline to post-task measurements suggest that the video game task was not sufficiently salient as a stressor to elicit a significant increase in the biomarkers being measured in the current study. The majority of participants in the study had limited experience playing video games with 34.4% of participants reporting playing video games for an average of 0 hours per week and 75% of participants playing 3 or fewer hours per week. More specifically, sex differences were observed in average amount of time spent playing video games per week. Men consistently dedicated the largest amount of time to playing video games in this sample with 45% of men reporting an average of 1-3 hours per week, 20.8% reporting 4-6 hours per week, 9.4% reporting 7-9 hours per week, and 3.8% reporting an average of over 10 hours per week. In contrast, only 35% of women reported playing an

average of 1-3 hours per week, 8.1% reported playing an average of 4-6 hours per week, and no women reported playing more than 6 hours per week. In this sample, 56.8% of women reported having no experience with video games while only 18.9% of men indicated the same.

Participants who report playing several hours of video games per week may have a greater psychological investment in the outcome of a game played against a stranger. If the task of playing a video game with an assigned partner in a cooperative or competitive fashion was not meaningful to participants, significant changes in the HPA and SNS systems would not be expected to be detected and would provide a suitable explanation for the unexpected results of the study. Although video games have been shown to be more salient stressors in male peer groups compared to females female groups because video games frequently mimic coalitional male-male competition (Geary & Flinn, 2002), it is reasonable to speculate that the game used in the current study, Bomberman, was not salient to male participants for the exact reason that it does not model coalitional male-male competition. In the case where a male participant is competing against a stranger on a non-violent videogame, there does not appear to be much potential for loss in terms of social esteem, respect, and perceived dominance, all factors known to elicit activity in the HPA and SNS stress systems. It is also possible that the video game task was salient as a stressor, but psychological immersion contributed to a deep focus on only the video game task itself, and not the social components of the task that were intended to activate the HPA and SNS stress systems. Indeed several video games are designed to integrate the concept of psychological flow (Sherry, 2004). If participants were completely immersed in the experience of playing the video game and not focused on cooperation or

competition with a partner, it is probable that HPA and SNS systems would fail to become active, or would activate very little.

In addition to a lack of task salience, uncontrolled anticipatory stress likely contributed to the surprising trend of decreasing CORT values over time as well as non-significant sAA changes. Previous studies have had success in accounting for anticipatory stress by instructing participants to complete questionnaires 15-20 minutes prior to engaging in the experimental task. Despite this study's use of the same tactic, the pattern of decreasing stress markers over time, even following activity intended to elicit a stress response, suggests that 20 minutes was not a sufficient amount of time for participants to habituate to the laboratory setting. Several authors have incorporated additional safeguards against anticipatory stress such as instructing participants to complete questionnaires on a day prior to completion of the task and playing classical music prior to participation in the experiment.

Considerable evidence exists linking psychological stress and cortisol activation in humans. Numerous studies have also documented a relationship between sAA and reactivity to social stress in the SNS (for review see Nater and Rohleder, 2009). The current collection of research taken as whole, suggests that the HPA axis and SNS stress systems both react to psychosocial stressors and interact with one another to produce a physiological response to threat. Because the current study was designed with the intention of preferentially eliciting HPA and SNS activity by emphasizing psychosocial stress in dyadic interactions, the results are particularly surprising. Studies investigating the relationship between psychological stress and cortisol activation have reliably shown it to be responsive to stressors that are perceived to be uncontrollable and present a type

of socio-evaluative threat. It is possible that participants in the current study had their HPA axis activated the most by the perceived lack of control associated with participating in a psychological experiment. It is also possible that the task of playing a video game cooperatively of competitively with an assigned partner simply didn't produce the desired social-evaluative threat that has been documented to activate HPA and SNS activity.

Despite the fact that none of the current study's *a priori* hypotheses were validated due to the pattern of decreasing CORT over time and non-significant findings for sAA, when viewing the results from within a framework of participant habituation to anticipatory stress, novel information concerning sex differences in stress reactivity is still provided. For change in CORT concentrations from baseline (time 1) to immediately following the social task (time 2), the effect of condition was found to be significantly more important for women than men. Results indicated that women habituated significantly faster in the cooperative condition (as measured by decrease in CORT from time 1 to time 2) compared to the competitive condition. Men, however, did not significantly change in their rate of habituation in response to cooperative and competitive social interaction.

Taylor et al. (2000, 2006) suggest that women may be particularly predisposed to affiliate under conditions of stress compared to men. The tendency to affiliate which is enhanced through the presence of estrogen and oxytocin release may serve to attenuate stress responses in females (McCarthy, 1995) and the stress-alleviating effects of oxytocin in females is documented to be long-lasting (Uvnas-Moberg, 1997). The results of this study appear to be consistent with Taylor's tend-and-befriend hypothesis. Due to

unique selection pressures acting on the development of neuroendocrine and social-cognitive functioning in women over time, it is posited that women are more likely to desire and respond with affiliative behaviors when faced with stress. Using the tend-and-befriend framework, it would appear reasonable to speculate that women habituated quicker to the anticipatory stress during the cooperative task compared to the competitive task because they were uniquely predisposed through their evolutionary heritage. Women, following to Taylor's hypothesis, should feel more comfortable in social situations were cooperation is encouraged over confrontation, allowing their HPA stress system to habituate and recover faster over time. In addition, according to Taylor's hypothesis, women should be less likely or slower to habituate over time when confronted with direct confrontation or competition. The fact that women in the competitive condition actually showed an increase in CORT from time 1 to time 2 appears to support this logical extension of Taylor's model. It was predicted that when engaging in a stressful task with a stranger, women would increase in CORT and sAA over time. Though the opposite was found, the significant change in habituation to stress from competitive to cooperative tasks suggest a strong tendency toward affiliative responses in women when they are cooperating with one another, regardless of whether they had previous experience with their partner or not.

Contribution of Research

The current study augments previous research assessing coordination of the HPA and SAM axes. To date, limited research has assessed the effect of shared activity on HPA and SNS activity concurrently. This study was, to the author's knowledge, among the first to empirically address how the sexes differ in stress responses to cooperative and

competitive activities by measuring CORT and sAA. Important information concerning how sexes differentially habituate to anticipatory stress in a laboratory setting was collected during this study. This novel information may be used as a basis for further research investigating sex differences in stress response to psychosocial stressors, particularly those that are competitive and cooperative in nature.

Limitations

Many of the statistical analyses in this study were lacking sufficient power to detect significant effects due to small sample size. Loss of data due to participant noncompliance and insufficient saliva collection largely contributed to a significantly reduced sample. Several saliva samples could not be assayed for CORT and sAA due to insufficient collection of saliva. Loss of data in this experiment, however, was random and not systemic. As previously discussed, a significant limitation of this experiment revolved around failure to adequately account for and control anticipatory stress in participants. Several measures should be taken in future studies to account for this confound which limits the testing of *a priori* hypotheses.

Conclusion

The current study aimed to augment the few previous experiments assessing the coordination between the two major components of psychobiological stress (i.e., HPA axis and SNS) in relation to shared activities between dyads. Although results of the study were counter-intuitive, with salivary CORT concentrations dropping over time, important information concerning how men and women differently habituate to cooperative and competitive tasks was provided. Women habituate to the stress of cooperative, social tasks quicker than tasks that require them to compete against a

stranger. This finding is consistent with Taylor's (2006) tend-and-befriend hypothesis that maintains that when confronted with stress, women are predisposed through their unique developmental history to affiliate with other persons. Similar studies in the future would benefit from controlling for anticipatory stress, limiting participant confounds associated with biobehavioral research, and ensuring the salience of their tasks designed to elicit a stress response through pilot testing.

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APPPENDICES

APPENDIX A

LIST OF VARIABLES

List of Variables

Questionnaire	Variables
1) Demographic Information	Age Ethnicity Marital Status Living Arrangement Socioeconomic Status Familial Level of Education Previous psychiatric/ psychological Tx Psychiatric/psychological Tx of relatives Religious Orientation Political Affiliation Previous experience with video games History of athletic competition
2) Health Information	Menstrual Cycle Length of cycles Regularity of cycles Days since last period Oral contraceptive use Pregnancy Use of Medications Health Conditions/ Diseases Body Mass Index (BMI)
3) Daily Health Screen	Overall health Fever presence Self-report feelings of being “flushed” Cold symptoms

Other Measures	Variables
1) Cortisol	Pre-task
	Post-task (immediate)
	Post-task (15 minute delay)
2) sAA	Pre-task
	Post-task (immediate)
	Post-task (15 minute delay)

APPENDIX B

IRB APPROVAL

Oklahoma State University Institutional Review Board

Date:	Friday, August 20, 2010
IRB Application No	AS1072
Proposal Title:	Physiological Responses to Video Games
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 8/19/2011

Principal Investigator(s):

Brandon J. Auer
116 North Murray
Stillwater, OK 74078

✓Jennifer Byrd-Craven
116 North Murray
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia H. Kennison

Shelia Kennison, Chair
Institutional Review Board

VITA

Brandon J. Auer

Candidate for the Degree of

Master of Science

Thesis: THE EFFECTS OF SHARED ACTIVITY ON DYADIC STRESS RESPONSE

Major Field: Psychology

Biographical:

Education: Graduated from C. Milton Wright High School, Bel Air, Maryland, in 2004; Attended Salisbury University, Salisbury, Maryland, 04'-05'; Completed the requirements for the Bachelor of Science in Psychology at Palm Beach Atlantic University, West Palm Beach, Florida in 2008. Completed the requirements for the Master of Science in Psychology at Oklahoma State University, Stillwater, Oklahoma in July, 2011.

Experience: Graduate student research assistant at Oklahoma State University (08'-09'), Instructor for Introductory Psychology at Oklahoma State University (09'-11'), Graduate Teaching assistant for Neurobiological Psychology at Oklahoma State University (Summer,11').

Professional Memberships: American Psychological Association student affiliate, member of GPSGA, member of Psi Chi Honor Society

Name: Brandon J. Auer Date of Degree: July, 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: THE EFFECTS OF SHARED ACTIVITY ON DYADIC STRESS RESPONSE

Pages in Study: 62 Candidate for the Degree of Master of Science

Major Field: Psychology

Scope and Method of Study:

The purpose of this study was to assess sex differences in stress responses to cooperative and competitive activities within same-sex dyads. Participants included 90 undergraduate college students. Salivary cortisol (CORT) was collected as a measure of stress reactivity in the hypothalamic-pituitary-adrenal (HPA) axis. Salivary alpha-amylase (sAA) was collected as a measure of stress reactivity in the sympathetic nervous system.

Findings and Conclusions:

Data were analyzed using a 2 X 2 analysis of variance, with condition (cooperative activity, competitive activity) and sex (male, female) as independent variables and salivary cortisol (CORT) and alpha-amylase (sAA) as the dependent variables. Results indicated a significant interaction between sex and condition for change in CORT from time 1 (baseline measurement) to time 2 (measurement immediately following shared activity). There was a significant difference in rate of CORT change from time 1 to time 2 for women in cooperative condition compared to the competitive condition. Specifically, women engaging in cooperative activity showed greater decreases in CORT from time 1 to time 2 than women engaging in competitive activity. There was no significant change in CORT for men during cooperative or competitive activity. No significant effects of condition or sex on sAA were observed.

ADVISER'S APPROVAL: Dr. Jennifer Byrd-Craven