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Chemical Communication: The Effects of Stress-Induced Apocrine Sweat on Human Perceptions and Interactions

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CHEMICAL COMMUNICATION: THE EFFECTS OF STRESS-INDUCED APOCRINE SWEAT ON HUMAN PERCEPTIONS AND INTERACTIONS

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For Matt, who is the best-smelling person I know. And for Zoey, who is the worst.

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ABSTRACT

In times of stress, humans secrete a type of sweat (apocrine sweat) that they do not secrete at any other time. This sweat has been previously shown to influence others who are exposed to it. The current project seeks to explore how apocrine sweat influences the people who are exposed to it. Using the framework of Emotional Contagion Theory, two studies were conducted to assess the effects of stress-induced apocrine sweat on human perceptions and interactions. Study 1 saw participants exposed to either thermoregulatory sweat or apocrine sweat before watching a short, fear-inducing video. Participants then reported their levels of psychological fear, physical fear, and how afraid they thought others would be in response to the video. Results indicate that exposure to apocrine sweat increases the level of fear reported, and that this effect is stronger for women than it is for men. The effect is consistent regardless of how susceptible one is to other forms of emotional contagion. Study 2 saw a romantic couple exposed to either thermoregulatory sweat or apocrine sweat before engaging in a conflict discussion. Participants then reported on their levels of anger and their partner's levels of anger as compared to their typical discussion about the topic. Results indicate that exposure to apocrine sweat is associated with a reduction in the couple's levels of anger. This effect was equally strong for men and women, and was not influenced by susceptibility to other forms of emotional contagion. Overall, results indicate that apocrine sweat has discernable effects on human perceptions and interactions.

CHAPTER ONE

INTRODUCTION

The sense of smell is regarded by many people as our least important primary sense (Haviland-Jones & Wilson, 2010). However, in 2004, the Nobel Prize in Medicine was awarded to Buck and Axel for their work in mapping the genes that allow for odor detection. Surprisingly, this single sense accounts for a whopping 3% of the human genome, a percentage that is second only to the immune system (Buck & Axel, 1991)! Widely under-researched and under-credited for its impact on human behavior, it is my belief that the sense of smell should no longer be seen as a largely disposable sense. In pursuit of this goal, this project seeks to identify how odors and odor detection (particularly human-generated odors) may subconsciously influence our interactions with others.

There has been a limited amount of research dealing with the influences of human-generated odors on human behavior, but the vast majority of these studies have dealt with the influence of purported "attraction pheromones," or odors which attract one mate to another for the purpose of reproduction. This project is more interested in the influences of another class of human odors: fear pheromones. Due to the composition and purpose of the different kinds of sweat glands on the human body, the presence of so-called fear pheromones seems likely (Chen & Haviland-Jones, 2000). Additionally, a limited number of previous studies supports the existence of these pheromones (De Groat et al., 2012; Mujica-Parodi et al., 2009, Prehn-Kristensen et al., 2009; Zhou & Chen, 2009, etc.). Using a Neo-Darwinian perspective on human communication, this project situates the well-documented mechanism of emotional contagion as the mechanism by which these pheromones work. In short, I seek to better understand how fear pheromones might induce certain emotional responses in those who are exposed to them.

The purpose of this dissertation is to explore the effects of the purported "smell of fear" (in the form of a specialized type of human sweat called *apocrine sweat*) on perceptions of a frightening stimulus and on displays of anger during a conflict discussion. In pursuit of these goals, the project involves two studies. Study 1 seeks to assess the effects of apocrine sweat on an individual's perceptions of fear. This study exposes participants to a mildly frightening stimulus and measures the effects of apocrine sweat on fear responses. Results indicate that exposure to apocrine sweat significantly increases experiences of fear and that these effects are stronger for women than they are for men. Study 2 seeks to assess the effects of apocrine sweat on displays of anger during a conflict discussion. This study asks a dating couple to discuss a topic they are frequently in conflict over and measures the effects of apocrine sweat on displays of anger. Results indicate that exposure to apocrine sweat significantly decreases experiences of anger during a conflict discussion.

This chapter is an introduction to the subject and purpose of the dissertation. Chapter 2 will review the literature relevant to odor detection, odor generation, odor effects on human behavior, and emotional contagion, as well as present rationales and hypotheses for the two studies. The next two chapters will present the methodologies, results, and discussions for Study 1 and Study 2, respectively. The final chapter is a discussion of the findings and their implications, as well as the limitations of the study and areas of future research.

CHAPTER TWO

REVIEW OF LITERATURE

This section begins with a brief overview of biological and evolutionary drivers of human communication before reviewing the biological components of odor detection and processing, the biological processes related to human odor generation, and the effects these odors have on human behavior. The chapter then examines the construct of emotional contagion, applying it to the behavioral responses to human scents previously outlined. The chapter concludes with hypotheses for two studies testing the effects of human body odor on human perceptions and behaviors.

Biological and Evolutionary Drivers of Human Communication

It is no secret that species change over time. In most cases, these changes occur as a way for the species to adapt to a changing environment. A relatively modern example of this process can be found in the Peppered Moth (*Biston betularia).* Prior to 1811, the Peppered Moth was predominately white-gray, which allowed it to escape predation by blending in with the light-colored bark of local trees. One in ten thousand moths (0.01%) was black, and—due to increased predation—these moths rarely lived to adulthood (Hart, Stafford, Smith, & Goodenough, 2010). Once the industrial revolution began, however, the environment of the Peppered Moth changed rapidly. Pollution from burning coal turned the local trees black, making the traditionally colored moths stand out, while allowing the darker moths to blend in. The effects of this environmental change were rapid and far-reaching. By 1895, 98% of all Peppered Moths were black (Berry, 1990). This was natural selection in action. The changing environment brought on by the industrial revolution altered the environmental pressures faced by the Peppered Moth. As a result, the individuals ill-suited to the new environment were eaten before they were able to pass along their now ill-suited genes. By contrast, the once poorly-suited individuals became

immensely more successful in their environment and it was *their* genes now propagating the species. As such, most modern Peppered Moths are black. Unless the environment presents a new challenge that makes being black less advantageous for a Peppered Moth's survival, the majority of the moths will continue to be black. In other words, traits will persist as long as they don't hinder reproductive success. Even if a trait is no longer necessary for the survival of the species (take the appendix in humans, for example), if it does not prevent an individual from procreating, that trait will persist.

In short, a bioevolutionary approach to understanding species-wide traits implies that the appearance of a particular trait or behavior in a modern organism is derived from the adaptive advantages that trait or behavior afforded to the organism's ancestors (Floyd, 2006). In other words, we look and act the way we do, because at some point in our evolutionary track, it was advantageous for our ancestors to look and act in those ways. Through the mechanism of natural selection, those advantageous traits were passed from parent to child over multiple generations. This is just as true for the Peppered Moth described above as it is for the human species—humans are not immune to natural selection stemming from environmental pressures. We evolved a bipedal gait because it gave us an advantage in hunting; we evolved thinner body hair and body-wide sweat glands because it gave us an advantage in thermoregulation. Perhaps our biggest evolutionary adaptation, however, is our intelligence. We are a highly intelligent species. We are so intelligent, in fact, that while other animals must evolve to better fit into their environment, we are able to make the environment fit us.

The primary way we alter the environment around us is through our use of tools (Vaesen, 2011). At some point in our evolutionary track, it was more advantageous to create tools to overcome environmental challenges than it was to evolve entirely new traits in order to adapt.

Indeed, tool-use is one of our defining characteristics (Vaesen, 2011). In my opinion, our most powerful tool is not a hammer or a jet engine or even a computer. Our most powerful tool is language. Language is a tool that allows us to coordinate with one another. After all, without language, could we ever hope to build a skyscraper? Even with the very best tools available to us, it would be impossible to accomplish without language. The incredible amount of coordination among individuals that language affords has allowed our species to advance at an unprecedented rate.

In terms of the evolution of communication, as early humans made their way in the world, the groups that developed language succeeded more readily than the groups without language. Thus, following the tenets of natural selection, language-users passed their genes along more often than non-language-users. But language-users did not only pass along the genes allowing them to speak, they passed along their knowledge about language as well. In this way, early humans created something of a second genome for the human species. Not only do we pass along our physical genetic code, we pass along our cultural genetic code as well. This cultural genetic code allows us to learn from long-dead ancestors or far-flung friends—something that is impossible for other species. And the ability to learn vicariously (rather than only learning through experience) has allowed us to progress even more rapidly than before. In short, the importance of modern language cannot be overstated—it is a pivotal adaptation for our species.

Language, however, did not develop all at once. It was undoubtedly a slow and arduous process. There were many generations of early humans who did not have language to help them communicate or coordinate with one another. Yet, nevertheless, early humans (and their more ancient predecessors) lived in groups where communication and coordination were important to the survival of all. What adaptations did early humans have to allow them to communicate with

their tribes? One primitive form of communication may have been smell. Early humans who could convey their feeling-state via nonverbal mechanisms such as smell may have been more successful than humans who could not. Similarly, humans who could understand the way a person was feeling simply by their smell may have also contributed to their tribe's success. In these ways, the sense of smell may have been an important element of communication prior to the development of language. Indeed, the biology behind the creation and detection of smell seems to demonstrate some evolutionary advantages for early humans. Further, the behavioral changes caused by certain smells provide further evidence that our ancestors communicated (at least in part) via smell. The next section of this chapter will be devoted to exploring the human sense of smell.

The Sense of Smell

In the 17th century, Sir Isaac Newton was perplexed that some substances could give off a strong odor for years and yet not suffer any observable loss of mass, while others gave off only a slight odor and dissipated rapidly (Kimble & Schlesinger, 1985). In the years after his death, scientific investigations revealed the reason for his observations: the olfactory system is not uniformly stimulated by all odorants. Instead, some substances can trigger the sensation of smell at one million times lower concentrations than other substances (Davies, 1971). Thus, a substance with highly effective physiochemical properties (for example, the ability to dissolve in water) can produce a potent smell while giving off only infinitesimal amounts of vapor. A few grains of musk (which Sir Isaac Newton preferred to use for his office) can perfume a room for over one million years before finally degrading (Cain, 1978). In short, all smells are not created (or perceived by the human brain) equally. What, then, are the factors in human smell

perception? The following is a review of the literature associated with the process of olfaction and the generation of human olfactory signals.

Olfaction

Olfaction is one form of *chemoreception*. Chemoreceptors (or chemosensors) work by converting chemical signals into action potentials (a brief event in which the energy potential of a cell rapidly increases and decreases, i.e. neurons facilitating cell-to-cell communication). In essence, a chemoreceptor detects chemical stimuli in the environment and transmits that information to the brain. Olfactory receptor neurons are classified as *distance chemoreceptors* (Shi & Zhang, 2009). These receptors detect chemicals in the gaseous state, and thus do not require direct contact with the chemical stimulant for detection to take place. By contrast, the taste buds are classified as *direct chemoreceptors* because they require physical contact with chemical compounds in order for activation to take place (Shi & Zhang, 2009). In other words, because taste buds are direct chemoreceptors, one cannot taste food from across the room. However, because olfactory receptor neurons are distance chemoreceptors, one *can* smell food from across the room. Closer proximity to an odorant yields a stronger olfactory response to that odorant. This is due to the concentration of odorant particles being higher near the odorant in question and lower further away. However, as previously mentioned, the chemical makeup of the odorant also contributes to its potency. Each distinct smell is comprised of a variety of smaller building blocks that contribute to its exact characteristics.

Due to the nature of the olfactory system, classifying these basic building blocks has proved exceptionally difficult, especially when compared to understanding our other primary senses. For example, when studying color vision, researchers examine the interactions between three wavelengths of light (red, green, and blue) and can then explain the occurrence of every

hue on the visible spectrum. This simplification has not been attained for odors. Perhaps this is because, unlike the eyes which have only three types of color receptors (red, green, and blue), the nose has approximately 1,000 types of odor receptors (Buck & Axel, 1991). And as each color receptor in the eye only recognizes a single wavelength of light (red, blue, or green), each olfactory receptor neuron only detects a single type of odorant molecule. While the entirety of color vision can be broken down into the perception of three interacting waves of light, the perception of odor starts at the interaction of 1,000 base smells. Each of these base smells interacts with the olfactory system in its own unique way, creating a complex sensory system. Despite these complexities, however, the basic process of odor detection and classification is the same for all odorants. This process is outlined below.

When activating the olfactory system, an odorant molecule is inhaled and comes into contact with mucus lining the nasal passages (Pinel, 2006). The mucus begins to dissolve the molecule while simultaneously putting the molecule in contact with odorant receptor neurons (ORNs) that line the olfactory epithelium (the skin inside the nose). The olfactory receptors clump together to form small structures called glomeruli. The nerves of the glomeruli pass directly to the brain via miniscule perforations in the cribriform plate (the bone separating the nasal passages from the brain) leading to the olfactory bulb. The olfactory bulb then relays information to the rest of the olfactory system in the brain. Here, multiple signals are synthesized together to form an overall perception of the olfactory stimuli (Morris & Schaeffer, 1953). This synthesis includes odor classification and recognition, reflex responses to odor (such as recoiling from ammonia), emotional responses to odor, and using visual and auditory cues to determine the source of an odor (Zelano, Montag, Johnson, Khan, & Sobel, 2007). Once the odor is relayed

to the brain, it is subjected to more refined neural processes to help the individual process the stimuli.

The olfactory system is the only mammalian sense that bypasses the thalamus to go directly to regions associated with higher brain functions (Shepherd, 2005; Ongur & Price, 2000). The thalamus is responsible for filtering through the massive amounts of information our bodies are constantly relaying to the brain to determine what is immediately relevant and what can be ignored. To demonstrate the thalamus in action, consider the following example: one's nose is constantly in one's field of vision. However, the thalamus decides that this visual information is unimportant and it is therefore filtered out of our conscious perception. If one were to apply zinc oxide or titanium dioxide for a day at the beach, however, one would find oneself constantly aware of the bright white coating directly beneath the eyes. Without the thalamus functioning to filter out irrelevant information, the brain would be continuously overstimulated. Because the olfactory system bypasses the thalamus, what prevents the brain from being overstimulated by the barrage of chemical odorants we are in constant contact with? The olfactory bulb has its own ability to modulate relevant information (Shepherd, 2005). The primary synapses in the olfactory system learn to filter odorant stimuli according to perceived importance through serotonin signaling. The influx of serotonin decreases excitation in the affected nerves and consequently disconnects olfactory neurons from their respective odor responses once exposure-related learning has taken place. In other words, the olfactory bulb uses simple associative memory at the site of its primary synapses in order to effectively "gate" the stimuli it is exposed to and avoid overloading the brain with irrelevant information (Li & Cleland 2013). Over time the nose learns to detect complex odorants against a background of chemical noise (Hudson, 1999; Stevenson & Wilson, 2007; Stevenson, 2010). In addition to simply

recognizing and processing odors, the olfactory system also assigns emotional and memory components to certain odors. This process will be briefly touched on below.

There are strong neural overlaps between olfaction and emotion (Phillips & Heining, 2002). Specifically, the olfactory bulb is part of the brain's limbic system (also called the "emotional brain," due to its close associations with memory and emotions). Furthermore, the olfactory system shares pathways with both the amygdala (the structure responsible for emotional processing), and the hippocampus (the structure responsible for associative learning). Thus, scents often trigger emotional reactions and memory recall (Guerin, 2008; Wilson & Linster, 2008). In animal experiments, studies have shown that exposure to an olfactory stimulus can be used to successfully condition subjects to fear (Cousens & Otto, 1998). In other words, olfactory stimuli alone are sufficient to trigger fear responses after the subjects have been conditioned to associate the odorant with a fear condition. However, when lesions are applied to the amygdala either pre- or post-training, the olfactory fear conditioning fails (Cousens & Otto, 1998). Thus, damage to the amygdala overrides the conditioning, leaving the odorant ineffective in triggering a fear response.

Interestingly, humans are also capable of responding to scents both physiologically and emotionally, and these responses can occur even when they are not consciously aware of any odor (Bensafi, Brown, Tsutsui, Mainland, Johnson, & Brenner, 2003). Being cognizant of an odor, much less being able to accurately identify that odor, is not necessary for generating a physiological or behavioral response. People are generally unaware that they are constantly detecting and processing chemical signals, and that many of these chemical signals are coming from equally unaware others.

Though the olfactory bulb and its related systems (outlined above) are responsible for the vast majority of odorant processing, they are not entirely responsible for the sense of smell. The trigeminal system is also an important component that should not be overlooked. The trigeminal system is responsible for the somatosensory (touch, proprioception, etc.) and motor (chewing, facial expressions, etc.) functions of the face and head (Brand, 2006). While the trigeminal nerve is not directly responsible for the sense of smell, branches of it do extend into the nasal lining, resulting in various interactions between the trigeminal system and the olfactory system. For example, the trigeminal system is responsible for the somatosensory experience smells give us. Ammonia causes irritation in the nasal passages because the trigeminal nerve interacts with the olfactory system and tells us that the chemical composition of ammonia is irritating. Thus, the trigeminal system is responsible for telling us if an odor is irritating or pleasing, sharp or mild, etc.

In addition to the olfactory bulb and the trigeminal nerve, there is one final component in the sense of smell, and this component contributes a good deal of controversy to the field. In many other animals, the Vomeronasal System (VNS) is responsible for the detection and processing of pheromones, which are chemicals emitted by members of a species that elicit behavior changes in others of the same species (Karlson & Luscher, 1959). A VNS is observable in the human fetus and in many adult humans, but it is not universal, and when it is present, it is not always functional (Meredith, 2001). Thus, some researchers argue that humans do not communicate via pheromones. However, there are many animals who communicate via pheromones who also do not have a working VNS (Dorries, Adkins-Regan, & Halpern, 1997). Further, research also demonstrates that humans are readily influenced by chemical stimuli from other humans (some of this research will be reviewed shortly). Whether these chemical signals

should be classified as “pheromones” or given some other moniker is a semantic debate that will not be addressed here as it is not the central focus of this project.

Individual Differences in the Sense of Smell

The male and female senses of smell are not created equally. Women have a more acute sense of smell than men and tend to outperform men on most olfactory-related tasks (Cain, 1982; Doty & Cameron, 2009). Under normal circumstances, the female olfactory system is at its strongest just before and during ovulation. It is suspected that females use the sense of smell to seek out the most suitable mate available to them. The female sense of smell also changes during pregnancy. During this time, women often report a much stronger sense of smell and a greater amount of sensitivity to noxious odors. They also report becoming nauseous at usually benign or even enjoyable odors (Cameron, 2007). Particularly offensive to many pregnant women are smells of meat and dairy.

Further individual differences arise from the genetic expression of the olfactory system. As Buck and Axel (1991) demonstrated, the genes coding for odorant receptor neurons (ORNs) comprise one of the largest gene families in humans (second only to the immune system). The presence or absence of a particular gene in this family corresponds to the ability or inability to detect certain smells. For example, one odorant receptor gene (OR2J3) allows us to detect the chemical compound related to “grassy” odors (McRae et al., 2012), and the gene coding for the receptor OR6A2 is responsible for enjoying the aroma of coriander (cilantro). Those without this gene express a general dislike for plants in this family (Callaway, 2012).

Human Odor Generation: Sweat

Before we begin to investigate how humans use odors in their daily lives, we must first understand where human body odor comes from. Human body odor consists of both a unique olfactory signature (the way you smell under neutral conditions), and another scent that arises

during times of physiological arousal. Both odors are linked to sweat; however, in times of physiological arousal, the composition of the sweat is altered, which leads to an altered odor. The process of sweat generation is outlined below.

As a general rule, humans are covered in bacteria. In fact, there are more cells in and on a person's body that are *not* genetically "them" than are (Sender, 2016). While some may find this knowledge unpalatable, it is important to remember that these bacteria are essential to our health and survival. In fact, the bacteria that the human body hosts are often considered an additional organ, as important to us as the lungs or kidneys (O'Hara & Shanahan, 2006; Lederberg & McCray, 2001). We have a symbiotic relationship with the bacteria that live on and in us. We provide the bacteria with food, and they protect us from harmful bacteria, help us digest our food, and keep us as healthy as possible. Those without adequate levels of the right kinds of bacteria open themselves up to a myriad of problems: eczema, Crohn's, acne, IBS, and anxiety/depression to name a few (Penders, Stobberingh, den Brandt, & Thijs, 2007). Why some people lack these bacteria has not been fully investigated and is not fully understood. Occasionally a cause can be traced (with systemic antibiotics being the most common culprit), but often the missing bacteria is a mystery. However, we do know that everyone has a unique set of bacteria, called a *microbiome* (Lederberg & McCray, 2001). The microbiome begins to develop at birth. Due to the sterility of the womb, a fetus will have no bacteria—good or bad—before its birth. The first exposure to bacteria is often from contact with the mother during the process of being born. Additional colonies are picked up throughout an individual's life—from the air, from the skin of other people, from anything they come in contact with (Hamady & Knight, 2009). One can sometimes deduce where an individual has traveled based off of the bacteria living on their skin. For example, certain bacteria are common in China, but largely

absent in North America, so if an individual's microbiome contains these bacteria, one might assume they have visited China at some point. However, this conclusion is not guaranteed. Because bacterial colonies can be picked up through mere contact, one may house a Chinese strain of bacteria after one's roommate or spouse visited the country.

Regardless of their origin, it is these bacteria that are responsible for the way one smells. While most people assume it is the sweat itself that causes body odor, this is a largely inaccurate assumption. The source of the odor is not the liquid secreted by the sweat glands; instead, it is the bacteria on the skin that *consume* that liquid that causes the odor. In other words, the smell of sweat is largely derived, not from the human producing it, but from the bacteria consuming it. To briefly explain, the skin is almost always secreting a small amount of sweat and oil (called *sebum*). The bacteria colonies on the skin use this for food. After eating the sweat, oil, and dead skin on the body, the bacteria create waste that is responsible for an individual's unique olfactory signature.

For the most part, the unique olfactory signature is neutral. In fact, most people are barely aware it exists; it runs in the background of our daily lives, only making its presence known when we walk into a loved one's house or are asked to identify who an article of clothing belongs to. However, there is another, more prominent smell that most people think of when mentioning the term "body odor." We spend billions of dollars every year attempting to eliminate or alter this smell. This body odor is not produced by all sweat glands equally. There is a reason why deodorant is only applied under the arms, rather than over the entire body: the environment under the arms and in a few other key places is much different than the rest of the body (Grice et al., 2009)—specifically, these areas differ in the types of sweat glands, the types of bacteria, and the type of hair present.

The majority of the human body is covered in eccrine glands, with the highest concentration of eccrine glands being found on the palms of the hands and the soles of the feet (Bolognia, Jorizzo, & Schaffer, 2012). Eccrine glands are small, pore-like structures which constantly secrete sweat. The sweat secreted by eccrine glands is a clear, odorless fluid consisting of water and salt. The primary function of the eccrine glands is thermoregulation. The sweat secreted by the eccrine glands is meant to evaporate quickly, thus cooling the body off (Wilke, Martin, Terstegen, & Biel, 2007). Apocrine glands, on the other hand, are concentrated in only a few places (primarily the armpits, though they are also present in the ears where they secrete earwax, around the areolas where they secrete breastmilk, and around the external sex organs and eyelids). The largest concentration of apocrine glands is around the axillary glands (i.e., under the arms) (Bolognia, Jorizzo, & Schaffer, 2012). Compared to other high-level primates, human axillary glands are both especially large and home to a particularly high concentration of apocrine glands (Montagna, 1964). The apocrine glands are present from birth, but remain dormant until hormonal changes occurring during puberty activate them (Krstic, 2004). Once activated, the apocrine glands are not constant producers of sweat the way that eccrine glands are. Instead, apocrine glands only secrete sweat during times of stress (Spearman, 1973). Further, the sweat secreted is drastically different from the sweat secreted by the eccrine glands. Apocrine sweat is an oily, white substance comprised of proteins, lipids, and steroids (Wilke, et al, 2007). This sweat is initially odorless, but rapidly changes upon bacterial activity. Sweat secreted by the apocrine glands does not evaporate quickly (as eccrine sweat does); instead, the composition of apocrine sweat causes it to linger on the skin. The type of hair found around the apocrine glands further facilitates the longevity of apocrine sweat (Grice et al, 2009).

Hair around the apocrine glands is thick, coarse, and wiry. This hair gives the apocrine sweat more surface area on which to spread out, allowing for a stronger odor to be cultivated.

Interestingly, the type of bacteria found on men and women differs. Women carry more *coccal* bacteria, while men are home to more *coryneform* bacteria (Jackman & Noble, 1983), though the reasons why or how this occurs are unknown. Interestingly, while the waste produced by *coccal* and *coryneform* bacteria smell quite similar, *coryneform* bacteria produces a much stronger smell. Thus, though must people cannot differentiate a male odor from a female one based on *how* they smell, then can distinguish male from female based on how strongly they smell (Jacob & McLintock, 2000). Men tend to have a stronger body odor than women. Just as there are sex differences in the type of bacteria consuming human sweat, there are also sex differences in the apocrine glands themselves. Women have 75% more apocrine glands than men; however, though men have fewer apocrine glands, they have much larger ones than do women (Brody, 1975).

In short, the characteristic scent of human body odor is derived from a specialized type of sweat (known as apocrine sweat) that is only secreted during times of stress. The odor of apocrine sweat arises from the bacteria that consume it, and the sweat has a much stronger smell than the more common thermoregulatory sweat because it offers both more for the bacteria to consume (in the extra chemicals and proteins secreted with it) and more time in which to consume it (due to the lingering effects of its composition). In other words, this sweat appears to be designed to be especially odorous. Because apocrine sweat is secreted when the individual is feeling stressed, it makes intuitive sense that others may be able to subconsciously deduce that there is a threat nearby when they are exposed to the apocrine sweat of another. Indeed,

preliminary research concerning the effects of fear chemosignals on human behavior seems to support this notion. The role of smell on human behavior will be outlined below.

Role of Olfaction in Human Behavior

The human sense of smell has three functions: ingestion, hazard avoidance, and social communication (Stevenson, 2010). When it comes to ingestion, the sense of smell serves to detect the location of food (Vickers, 2000), determine a food's suitability for ingestion (Fallon & Rozin, 1983; Yeomans, 2007), create associative memories about prior ingestive episodes (Cannon, Best, Batson, & Feldman, 1983; Zellner, Rozin, Aron, & Kulish, 1983; Baeyens, Eelen, Crombez, & Van den Bergh, 1990; Capaldi & Privitera, 2007; Yeomans, Chambers, Blumenthal, & Blake, 2008), and regulate (through stimulation and inhibition) appetite (Cabanac, 1971; Rolls, 1981; Birch, McPhee, Steinberg, & Sullivan, 1990; Hetherington, 1996).

The use of the olfactory system to detect danger in the environment is clearly evidenced by the use of volatile compounds (such as sulfur) to signal the presence of odorless hazards in the environment (such as natural gas) (Cain & Turk, 1985). Further, certain chemicals associated with biological decay result in strong avoidance behaviors (Rozin, Haidt, McCauley, Dunlop, & Ashmore, 1999). In fact, the use of the olfactory system for hazard detection is often divided along these two lines: nonmicrobial hazards (poison, fire, predators, etc.) and microbial hazards (feces, vomit, decomposition of organic matter, etc.). Each broad category results in a different emotional response to the stimuli. For nonmicrobial hazards, the most common emotional response is fear; for microbial hazards, the most common emotional response is disgust (Stevenson, 2010). There is evidence to suggest that fear responses in reaction to nonmicrobial threats are at least partially innate rather than learned (Khan et al., 2007; Kobayakawa et al., 2007). It is possible (though certainly not confirmed) that humans have adverse reactions to certain chemical signals because they have been reliable and consistent indicators of danger in

our ancestral history (Stevenson, 2010). Those without a sense of smell (anosmics) and those with a significantly weakened sense of smell (hyposmics) have a significantly more difficult time detecting environmental hazards such as burning food (Temmel et al., 2002), gas leaks (Miwa et al., 2001), and smoke (Santos, Reiter, DiNardo, & Costanzo, 2004). It has even been suggested that a significant number of deaths related to coal gas poisoning prior to switching to natural gas were the result of elderly people suffering from hyposmia failing to detect the hazardous smell (Chalke, Dewhurst, & Ward, 1958). While natural gas is deemed safer than coal gas, many elderly people may still fail to detect a leak due to weakening olfactory senses (Cain & Turk, 1985).

In terms of microbial threats, the olfactory system serves to induce disgust and subsequent avoidance to these stimuli; this reaction is at least partially a learned response (Rozin et al., 1999; Stevenson, 2010). Adults exposed to these types of odors exhibit far stronger reactions than children, with children under 3 years old exhibiting the fewest disgust behaviors. It has been suggested that exposure to these stimuli actually stimulates the immune system to prepare for a microbial attack (Ramirez-Amaya & Bermudez-Rattoni, 1999; Hosoi & Tsuchiya, 2000; Rubio-Godoy, Aunger, & Curtis, 2007; Moscavitch, Szyper-Kravitz, & Shoenfeld, 2009).

The final function of the olfactory system is that of social communication (Stevenson, 2010). Social communication via chemosignals can be divided into three general areas: information about familial relationships, information about mate suitability, and information about emotional states. Each of these categories will be reviewed below.

Family Relationships

Much as each person has a unique fingerprint or voice print, each person also has a unique olfactory signature (Niolaides, 1974). Dogs can easily identify which human has entered a room

simply by the unique smells each human leaves behind. It is this ability to recognize human olfactory signatures that makes well-trained dogs key members of many search-and-rescue teams. . Further, it is well documented that many of our physical traits, including the way we smell, are inherited from our family via genetics. Thus, in addition to inheriting a parent's nose, you may have also inherited a parent's smell.

In one study (Russell, Mendelsen, & Peeke, 1983), infants wore a plain t-shirt for several days. Later, the infants' mothers were asked to choose which t-shirt was worn by their child. Ninety-four percent of the mothers participating in the study were able to identify the clothing of their child by smell alone. In another study, infants were exposed to a pad with their mother's lactic scent and a pad with another woman's lactic scent. The infants were able to distinguish between the two pads and responded to that smell by turning their heads in the direction of their mother's smell, but not towards the other woman's smell (Macfarlane, 1975). Porter and Moore (1981) asked both mothers and fathers to identify which clothing belonged to their children. Additionally, the parents were asked to distinguish between the clothing worn by each of their children (could the parents tell which shirt belonged to their youngest daughter and which belonged to their middle son, for example). Eighty-nine percent of the parents were able to successfully identify which clothing belonged to their children in general *and* which clothing belonged to which child specifically. Siblings were also able to identify each other through smell alone. In the same study design, 79% of the participants were able to correctly identify which t-shirt was worn by their sibling (Porter, Balogh, Cernoch, & Franchi, 1986).

When it comes to the human ability to identify kinship based on human odors, the studies outlined so far could easily be attributed to learned associations. After all, when you have lived your life with a person, you tend to be able to recognize many things about them. And if this was

as far as the phenomenon extended, it would still be quite intriguing—after all, we typically think of human odor recognition as something only dogs and other species with strong noses can do. However, there is evidence that it goes much further than a simple learned association. In fact, the evidence seems to suggest that we are capable of smelling kinship through shared genetic phenotypes just as we are capable of seeing kinship through shared physical features. For example, before they had had a chance to meet their newborn grandchildren, grandparents were given a range of t-shirts to smell. These grandparents were able to successfully choose which t-shirt belonged to their grandchild, even though they had never met (Porter, et al, 1986). In another study (Porter, Cernoch, & Balogh, 1985), mothers and their children were each asked to wear a plain t-shirt. People who had never met any of the participants engaged in two matching exercises. They were asked to smell a child's shirt and determine which of the offered shirts belonged to the child's mother, and they were asked to smell a mother's shirt and select which of the offered shirts belonged to her child. In both tests, participants were able to successfully match the mother and child at a rate greater than chance. In order to determine if this ability stemmed from similar environments rather than similar genetics, the researchers ran a similar experiment with co-habitating husbands and wives. When asked to identify which shirts belonged together, the participants were unable to do so at rates greater than chance. In other words, evidence suggests that using olfaction to identify family relationships results from blood relationships, not shared living environments. It is believed this blood relationship is chemically expressed by the major histocompatibility complex (MHC)—a major part of the immune system. Evidence suggests that an individual's MHC is detectable by the olfactory system and that kinship relationships can be observed in this manner (Levy & Keller, 2009).

While we are unable to detect which two individuals have pair-bonded through smell alone, we actually do use our sense of smell in the romance department. Rather than evaluate who of a group of strangers is paired with whom, we use smell to determine who we ourselves should pair with.

Attraction

Though still an under-researched area in general, the role of human olfaction on reproductive behavior has enjoyed the most scholarly attention (Hassett, 1978; Kohl & Francoeur, 1995; Stevenson, 2010, etc.). Research supports the idea that olfaction has a clear role in human sexual behavior.

On a small section of the sixth chromosome there lies a very important bundle of genetic code. This bit of code is responsible for the Major Histocompatibility Complex (MHC), sometimes known as Human Leukocyte Antigens (HLA). These antigens are found on the surfaces of cells and help tell the body's immune system what is a threat to the system and what is a harmless part of the body. The body's immune system analyzes the antigens found on each cell it encounters and determines if it is "self," (and should therefore be left alone) or "non-self," (and should therefore be attacked). In this way, your MHC makes up a very important part of your immune system.

MHCs/HLAs first rose to prominence in organ transplants. Doctors found that many organ recipients would reject the new organ and the immune system would attack it as a foreign body. This reaction was (and still is) less likely to happen if the donor and the recipient have similar MHCs. If the two people have matching antigens, the immune system will see the new organ's cells as "self," rather than "non-self." If you are ever in need of an organ transplant or a bone marrow donation, you are paired with someone who has an MHC that matches your own. Most

people are significantly more likely to find a match from someone who has a similar ethnic background (with siblings being the clear favorite in the donation community). In essence, the immune system is more likely to see an organ from another person's body as "self," if that person has a similar ancestral background.

While genetic similarity is beneficial when it comes to organ transplants, it is detrimental in other situations. Humans look for genetic diversity in their mates. Without diverse genes, we—as a species—would be much more vulnerable to extinction due to diseases and environmental stressors. It would be detrimental to us as a species if we valued genetic similarity over genetic diversity. In fact, if genetic similarity was advantageous, humans probably would have evolved to be asexual beings—reproducing by making copies of ourselves—rather than sexual beings—reproducing by pairing with other humans. For a real-world example of what happens to a species without enough genetic diversity, consider purebred dogs. These dogs have many more genetic diseases than mixed breeds. In essence, the purebred animals do not have enough genetic diversity in their breeding pools to average out any negative genetic traits. Instead, those negative traits get magnified over time, rather than lessened. This is the precise reason why humans seek out genetically diverse individuals to mate with.

While the exact mechanism is not understood, evidence suggests that the human olfactory system is sensitive to reproductive chemosignals (Keverne, 1999; Baum & Kelliher, 2009; Touhara & Vosshall, 2009; Liberles & Buck, 2006). Indeed, differences in MHC types appear to be detectable through the odor produced by human sweat (Zavazava, Leimenstoll, & Muller-Ruchholtz, 1990). There is evidence that humans are able to detect similar and dissimilar MHCs based on smell alone (Wedekind, Seebeck, Bettens, & Paepke, 1995; Chaix, Cao, & Donnelly, 2008; Wedekind & Furi, 1997; Ober, Weitkamp, Cox, Dytch, Kostyu, et al., 1997; Ziegler,

Kentenich, & Uchanska-Ziegler, 2005). We generally find the smell of a person with a different MHC from ours to be more sexually appealing than the smell of a person with a similar MHC. For example, Wedekind, et al (1995) asked a group of men to wear a plain cotton t-shirt for two days. These t-shirts were then placed in opaque boxes and a group of women was asked to smell and then rate the t-shirts for intensity, pleasantness, and sexiness. Afterwards, the men and women underwent tests to determine their MHC types. After examining the data, the researchers found that women thought men with different MHC types from their own smelled far sexier than the men with MHCs similar to theirs. In short, the women smelled a set of antigens they didn't have, and were very attracted to them. Additional research has largely confirmed these findings. Further, female participants describe the smell of a potential mate as one of the most important factors in assessing that mate's attractiveness (Franzoi & Herzog, 1987; Herz & Cahill, 1997; Herz & Inzlicht, 2002).

The reproductive functions of the olfactory system appear to serve two primary functions: avoiding inbreeding (Penn & Potts, 1998) and detecting genetic fitness in potential mates (Stevenson, 2010). Inbreeding is a significant danger to any offspring born of such a union—often resulting in cognitive deficits and poorer immune function (Ross-Gillespie et al., 2007; Ilmonen et al., 2008). In human studies, mates with a high degree of MHC similarity tend to have higher rates of miscarriage (Beer et al., 1985; Ober et al., 2003) and babies born to such a pair tend to have lower birth weights (Reznikoff-Etievant et al., 1991). Instead, offspring benefit most from what Bateson (1983) termed *optimal outbreeding*, or selecting a mate that is different from oneself, but not *too* different.

While this seems very cut-and-dried on its face (it does readily explain the utter lack of chemistry you may have with someone whom you *know* is very attractive), further research

begins to complicate matters a bit. Women, as it turns out, are attracted to different MHC types at different points in their menstrual cycles (Thornhill, Gangestad, Miller, Scheyd, McCollough, & Franklin, 2002). Immediately following menstruation until the peak of fertility during ovulation, women prefer men with a different MHC from their own. During menstruation or pregnancy, however, women showed the greatest preference for men with a *similar* MHC to their own. As a woman's fertility fluctuated, her ideal mate also altered. The prevailing explanation for this phenomenon contends that, leading up to and during fertility, a woman is subconsciously seeking out a genetically diverse man to mate with. After ovulation and during either menstruation or pregnancy, the same woman seeks out men who are genetically similar to her. Seeking genetic diversity when she is most likely to conceive a child serves to ensure the child will have all the advantages that come with genetic diversity. Conversely, seeking genetic similarity when conception is least likely (or impossible if she is actually pregnant) may be a defense mechanism for the woman. As previously mentioned, genetic similarity is associated with shared ancestry. In other words, seeking genetically similar people is essentially seeking the company of family members. Family members tend to be very protective of each other (one of the perks of being social animals); thus, the explanation goes, the pregnant or menstruating woman seeks out kinsmen during the times when reproducing is not possible to ensure she is protected by her family.

This interesting phenomenon becomes even more interesting when one considers the use of hormonal birth control pills. Hormonal birth control works by preventing a woman from ovulating. If she does not ovulate, she cannot conceive a child. Additionally, if she does not ovulate, she is primarily attracted to similar MHC types, rather than different ones. And studies confirm this. Wedekind and Furi (1997) demonstrated that women on hormonal birth control

preferred the smells of men with similar MHCs at any point in the month, while women not using hormonal birth control preferred the smells of different MHCs during ovulation and similar MHCs during menstruation.

Not only are humans able to smell who is a more genetically compatible mate, we also have the ability to smell when the chances of conception are most probable. Men appear to be able to tell when a woman is ovulating (and thus able to conceive a child). In one study by Singh and Bronstad (2001), women were asked to wear a plain t-shirt during ovulation and another plain t-shirt while not ovulating. After smelling them, men rated the t-shirts worn during ovulation as more pleasant and sexier than the t-shirts worn outside of ovulation. In a similar study (Havlicek, Dvorakova, Bartos, & Flegr, 2006) women were asked to wear cotton pads under their arms during menstruation, ovulation, and the luteal phase of their menstrual cycle (the time between ovulation and menstruation). Men rated the odors of women during ovulation as the least intense and the most sexually appealing of the three categories. Because differences found in a lab don't always translate to differences in behavior outside of the lab, Miller, Tybur, and Jordan (2007) conducted a study to determine how ovulation influences the real-world behavior of men. They chose a strip-club to conduct their research. This study asked two groups of strippers—those taking hormonal birth control and those cycling normally—to track their tips and their menstrual cycle for two months. The normally cycling strippers averaged $185/shift while menstruating, $260/shift during the luteal phase, and $335/shift during ovulation. As you can see from these numbers, there was a distinct spike in the value of tips the women received during ovulation. For women taking hormonal birth control, there was no such earnings spike. Instead, earnings remained relatively stable throughout the month. This suggests that hormonal birth control may have significant effects on mate selection through the sense of smell. However, that is not the

only everyday behavior the sense of smell may be silently influencing. One's emotional state—particularly the state of fear or stress—may also be part of the olfactory system's domain.

Fear

The idea that fear is an emotion that comes with an odor is not a new one. And as it turns out, science largely confirms the presence of fear-related odor. Individuals are able to detect chemical signals emitted by another stressed individual and these signals appear to enhance subsequent vigilance for the observer (Valenta & Rigby, 1968; Stevenson, 2010). In some cases, this perception appears to be conscious rather than subconscious, with female participants correctly identifying sweat collected from fearful donors (Ackerl, Atzmueller, & Grammer, 2002). Beyond conscious identification, there appear to be a number of subconscious responses and effects generated by the exposure to fear chemosignals. For example, women exposed to these odors performed better on a word association task than those exposed to neutral odors, suggesting an increase in mental processing speed due to the chemosignals they were exposed to (Chen, Katdare, & Lucas, 2006). Men also exhibited a greater startle blink reflex when exposed to fear chemosignals, again suggesting enhanced vigilance after exposure (Prehn, Ohrt, Sojka, Ferstl, & Pause, 2006).

Prehn-Kristensen et al. (2009) found that humans are subconsciously affected by the emotional odors of others. In this experiment, sweat was collected from the backs of students on exercise bikes or from under the arms of students about to give a speech in class. While lying on fMRI scanners, a third group of students were exposed to one of the two types of sweat and then asked to evaluate what they smelled. While respondents did not indicate that there was a direct effect of either odor on their emotions, the fMRI showed increased activity in the areas of the brain involved with empathy and emotional states for the fear condition but not the exercise

condition. Further, Zhou and Chen (2009) found that those exposed to sweat collected during a fear condition were more likely to rate ambiguous faces as being fearful than those exposed to sweat collected during a humor condition or a control condition.

De Groot et al. (2012) found that humans are susceptible to both fear odors and disgust odors. Sweat was collected from individuals watching scenes from either a scary movie or the movie *Jackass* (a film involving adults intentionally hurting themselves or exposing themselves to revolting situations). Another group was asked to take a visual test while they were unknowingly exposed to these scents. Shortly after the smells were released into the room, those exposed to the fear condition made facial expressions consistent with a fear response (widened eyes, opened mouth, flared nostrils, etc.). Those in the fear condition also took deeper and more frequent breaths, scanned the environment more, and fixed their gaze on the exercise less. Similarly, those exposed to the disgust condition made faces indicating disgust (wrinkled nose, furrowed brow, and puckered mouth). In other words, those exposed to the emotional odors of others experienced congruent emotions. The smell emitted by one individual in response to fear caused a similar response in others. Even though we are neither consciously aware of producing a fear odor, nor actively engaged in interpreting that odor as indicative of fear and danger, our sweat seems to be communicating those things nonetheless.

There are mixed results concerning sex differences in decoding the chemosignals emitted by others. One study found women were more likely to respond to the chemical emotional signals of others than men (de Groot, Semin, & Smeets, 2014). Female participants emulated the facial expressions of fear when exposed to the fear chemosignals of others while males did not. However, another study using only male participants found that males were also capable of being influenced by fear chemosignals (Zernecke, et al, 2011). Male sweat was collected during a fear

condition and an exercise condition. This sweat was applied to another group of male volunteers. These volunteers then rated the facial expressions of others. Men were significantly more likely to rate ambiguous faces negatively when exposed to the fear chemosignal condition. Those in this condition were also more likely to rate happy faces as being less happy than those in the exercise condition. In a similar study, women were also susceptible to influence via fear-related chemosignals. After exposure to fear sweat, women were more likely to perceive ambiguous facial expressions as being more fearful than those who were exposed to a control condition (Zhou & Chen, 2009). This effect was not present when the facial expressions were easier to interpret.

Recent research has begun to shed light on the question: how important are fear chemosignals in the face of other, more traditional avenues of communicating emotions? The majority of scientific thought would suggest chemosignals are easily overridden by auditory or visual signals about emotional states. However, research demonstrates that olfactory stimuli were just as powerful as audiovisual stimuli in generating a fear response (de Groot, Semin & Smeets, 2014). These findings held true whether the audiovisual stimulus and the olfactory stimulus confirmed each other (both exhibited fear or both exhibited no fear) or contradicted each other (one exhibited fear and one did not).

Odor as Nonverbal Communication

Nonverbal communication takes many forms. Some forms (such as gestures) are largely planned and intentional (Knapp, Hall, & Horgan, 2014). Other forms are subconscious and largely uncontrollable (height and physical attractiveness, for example). In regards to the infamous statement from Watzlawik, Bavelas, and Jackson (1967), "one cannot not communicate," this project was conducted from the position that that one *can* not communicate, but that one usually *is* communicating, regardless. From this perspective, behavior need not be

conscious or intentional to qualify as communication. Instead, if one of the primary functions of a behavior is to provide information or in some way influence another person, that behavior is communication. Thus, regardless of whether we are conscious of a nonverbal behavior or whether we can actively control and alter a nonverbal behavior, it can still be considered nonverbal communication insofar as it is designed to provide information to another person. In short, even though something is not within our conscious control, it can still be used to communicate with other people.

Take for example, the facial expression associated with fear. This face is characterized by widened eyes, raised eyebrows, flared nostrils, and an open mouth (Ekman, 2003). The facial expression serves two primary functions. First and foremost, it opens up the sensory surfaces, allowing for greater intake of oxygen, easier identification of dangerous odors, and faster, more accurate visual perception. In short, it improves our ability to sense danger and thus escape from harm's way more effectively (Anderson & Susskind, 2008). Secondly, however, the fear expression functions as a way to signal to others that there is danger nearby. When we recognize one person's fearful facial expression, we understand that that expression is indicative of a potentially dangerous situation. Thus, the function of the facial expression of fear is two-fold: first it serves as a way of preserving the self, and second it serves as a way of preserving others.

Therefore, under certain circumstances, body odor falls within the category of nonverbal communication. Evidence suggests that humans use odors to communicate emotions (Haviland-Jones & Wilson, 2010). While the emission of mood odors may not be consciously done, the scents are used to communicate nonetheless. From an evolutionary perspective, sweating in response to stress serves two purposes. First, it keeps the individual cool, thus allowing for a

more powerful fight or a swifter flight. Second, it creates an odor that signals to others that there is danger nearby.

As has been previously discussed, humans have two types of sweat glands that produce two types of sweat (Folk & Semken, 1991). Sweat from the eccrine glands is primarily used for thermoregulation (i.e., cooling). Sweat from the apocrine glands does little to contribute to cooling the body, but is instead a response to stress. This sweat is designed not to evaporate, but to remain on hair, thus affording bacteria the chance to grow and consume it. In other words, humans have a form of sweat that seems specifically intended to produce body odor. What purpose, then, does this odorous sweat serve? It seems plausible that this type of sweat is designed to indicate danger to nearby humans, thus preserving additional members of the species from impending doom. In other words, body odor can be a form of nonverbal communication via the mechanism of emotional contagion. In the next section, I will briefly review literature on the importance of emotions in conflict, before turning my attention to a review of emotional contagion.

Emotions and Conflict

Arguments and disagreements are unavoidable in a sufficiently long relationship. If two people spend enough time together, there will come a time when they do not see eye-to-eye on some issue or another. Disagreements are part of every relationship. Contrary to popular belief, however, it is not how often a couple argues that determines its happiness, but how a couple argues in general that most affects the satisfaction of its members. As Jones (2000) points out, conflict is emotionally defined. Indeed, the emotions experienced and displayed during relational interactions are of vital importance to both the overall health of the relationship (Greenberg & Goldman, 2008; Johnson & Greenberg, 1994; Fletcher & Thomas, 2000) and to the individual

partners' personal well-being (Mead, 2002; Hautzinger, Linden, & Hoffman, 1982). Conflict most often occurs when negative emotions (anger, fear, guilt, jealousy, etc.) arise (Jones, 2000). Empathic accuracy, or the ability of spouses to correctly interpret their partners' emotions during relational conflict, is positively associated with improved quality of communication during the conflict and with increased likelihood of reaching a resolution to the conflict (Fruzzetti & Iverson, 2006). Empathic accuracy stems not only from information derived directly from one's spouse, but also from information about oneself which is used to infer how one's spouse is feeling during a conflict (Papp, Kouros, & Cummings, 2010).

Specific emotional displays have varying effects on the relationship. For example, anger is usually identified as the strongest and most powerful emotion displayed during relational conflict; it is also the most easily identified (Greenberg & Goldman, 2008). Anger may escalate quickly and often occurs in cycles (Greenberg & Goldman, 2008; Jenkins, 2000). The effects of anger during a conflict are varied, with some research indicating that anger-displays lead to increased concession-making (Li & Roloff, 2006; Sinaceur & Tiedens, 2006) and other research demonstrating that anger-displays are associated with retaliation and decreased empathy (Allred, 1999; Allred, Mallozzi, Matsui, & Raia, 1997). As Van Kleef, Van Kijk, Steinel, Harinck, & Van Beest (2008) demonstrated, the interpersonal effects of anger differ depending on the nature of the relationship and the reported justification for the anger display. Sadness, on the other hand, is associated with feeling alone or isolated, and may indicate poor relationship quality; it is also more difficult to identify than anger (Greenberg & Goldman, 2008). Fear in relational conflict has been much less frequently studied than anger or sadness, but it most typically signifies a couple in distress or a couple recovering from a traumatic event (e.g., following infidelity) (Greenberg & Goldman, 2008).

Individuals typically harbor expectations about the probability of their romantic partners becoming angry or aggressive following a relational complaint (Cloven & Roloff, 1993). If the expectation is that the encounter will become intense, individuals will often resort to avoiding the conflict altogether (Gelles & Straus, 1988; Cloven & Roloff, 1993; Guerrero & Afifi, 1995). Ironically, if avoidance is not possible, individuals who expect an emotionally intense conflict actually engage in behaviors that facilitate its occurrence, making the expectation of an intense conflict a self-fulfilling prophecy (DiPaola, Roloff, & Peters, 2010). Once engaged in conflict, emotional displays may elicit reciprocal (anger→anger) or complementary (anger→guilt) responses in the relational partner (Butt, Choi, & Jaeger, 2005; Steinel et al., 2008).

In terms of individual responses to relational conflict discussions, there are some sex differences that emerge. For example, women often undergo greater physiological reactions to conflict interactions than do men (Kiecolt-Glaser & Newton, 2001; Smith et al., 2011). Maintaining relationship quality in the face of conflict requires regulation of emotional experiences, emotional expressions, and other social behaviors, and women often put forth greater effort in these areas than men (Smith et al., 2011). When it comes to empathic accuracy, men's ability to correctly identify their partners' emotions was moderated by women's depressive symptoms, such that as a woman's depressive symptoms increased, the man's empathic accuracy decreased. This moderation effect was not observed when it was the man exhibiting greater depressive symptoms (Papp, Jouros, & Cummings, 2010). In short, men and women both exhibit high empathic accuracy when their partner does not suffer from depressive symptomatology. However, when their partner does exhibit symptoms of depression, men are not as accurate in assessing their partner's emotional state while women retain their previous levels of accuracy. Regardless of sex differences, the nature of relational arguments makes them

an excellent place to explore the effects of emotional contagion, a concept which will be reviewed in more detail below.

Emotional Contagion

Emotional contagion is the tendency for two individuals to emotionally converge through automatic mimicry and synchronization of one person's expressions, vocalizations, postures and movements with those of another person (Hatfield, Cacioppo, & Rapson, 1993). When people unconsciously mimic their companions' expressions of emotion, they come to feel reflections of their partner's emotions. Emotional contagion occurs when "precipitating stimuli arising from one individual act upon one or more other individuals, and yield corresponding or complementary emotions in these individuals" (Hatfield, Cacioppo, & Rapson, 1994, p. 5).

Emotional contagion (sometimes called "primitive empathy") has been with the human species for a very long time. It helped our ancestors understand each other in a time before language, when they could recognize fear, for instance, by having the same feelings induced in them, thus helping them survive potential danger. It is even present in us at birth. One crying infant will set off a wave of crying in a hospital ward. Studies also show that infants and children mirror the facial expressions of the primary caregiver, suggesting that they feel the same emotions too, or at least that their nervous system is reacting to the emotions of the caregiver (Field, Woodson, Greenberg, & Cohen, 1982; Meltzoff & Moore, 1989).

Emotional contagion is comprised of four basic components: shared neural representations, self-awareness, mental flexibility, and emotion regulation (Balconi & Bortolotti, 2012; Decety & Jackson, 2004; Farrow & Woodruff, 2007). Some components occur automatically or subconsciously, for instance affective sharing (Balconi & Lucchiari, 2005; Hoffman, 1984; Yamada & Decety, 2009), while other components require intentionality, such as mental flexibility and emotion regulation. In other words, the process of emotional contagion

entails both conscious perceptions of a social situation and automatic, subconscious responses to the behaviors observed therein. Nonetheless, responses to emotional displays tend to follow a set, three-stage process. First, the perception of facial expressions leads to automatic, subconscious facial mimicry (Chartrand & Bargh, 1999; Dijksterjuis & Barth, 2001). Second, neural receptors involved in facial movements provide afferent feedback in regards to these facial expressions. Finally, corresponding or complementary emotions are evoked in the observer (Hatfield, Cacioppo, & Rapson, 1992). This process allows the actions and feelings of individuals to become synchronized, enhancing the chance of reacting appropriately in a given social situation (van der Schalk et al., 2011).

It is important to note that emotional contagion is not a shared *experience*, but rather a shared *emotion*. When two people experience the same event, they can have a conversation about their respective feelings in regards to that shared experience. Sometimes, these feelings will align, and sometimes they will differ, but each person's feelings are their own. Emotional contagion, on the other hand, occurs when only one person experiences the event, yet both individuals come to feel the same emotions after interacting with one another (Siebert, Siebert, & Taylor-McLaughlin, 2007). Further, emotional contagion is not the same thing as pure empathy. Empathy involves identifying or understanding the emotions of another (in other words, "feeling for"), while emotional contagion causes an individual to *physically feel* the emotions of another person (in other words, "feeling with") (Miller, Birkholt, Scott, & Stage, 1995).

This ability to "feel with" has important social implications. Individuals readily recognize that consciously analyzing other people can glean a great deal of information about those people. However, most seem less aware that they can gain additional information by focusing on their *own* emotional reactions to others during social encounters (Hatfield, Cacioppo, & Rapson,

1993). As people subconsciously mimic the expressions of emotions exhibited by their companions, they often come to experience weaker reflections of their partners' own feelings. Focusing on these reactions to others can allow well-tuned people to essentially "feel" themselves into the emotional states of their partner. In one study (Hatfield, Cacioppo, & Rapson, 1992), when asked what their conversational partner "must be feeling," participants relied most heavily on what their partner said, rather than any nonverbal cues relaying their emotional state. However, when the participants were asked how they themselves were feeling, their emotions more closely resembled the nonverbal cues exhibited by their partner. In essence, if the participants had paid closer attention to their own feelings in response to the interaction with their partner, they may have gotten a clearer or more accurate understanding of their partner's own emotional state. In fact, if they had paid closer attention to merely their own facial expressions in response to their partner's communications (never mind their own feelings in this regard), they might have seen this benefit, as facial reactions are a known precursor to emotional contagion.

That individuals viewing the facial expressions of others (either through direct contact or through pictures/videos) engage in motor mimicry of those facial expressions is a well-documented phenomenon (Hatfield et al., 1994; Walbott, 1991; Dimberg & Lundqvist, 1990; Dimberg, 1982, Doherty, 1998, etc.). Facial mimicry is often conceptualized as an automatic, reflex-like response (Hoffman, 1984; Hatfield et al., 1993) that enables an observer to experience and subsequently communicate empathy to the observed (Rogers, 1975) and that fosters greater understanding between observer and observed (Siegel, 1995). Further, this motor mimicry is often associated with corresponding imitations of emotions (Hatfield, et al., 1993; Strayer, 1993; Laird et al., 1994; Lundqvist & Dimberg, 1995). It is often suggested that the imitated expression

is a causal factor in the appearance of emotional contagion via facial feedback (Hoffman, 1984; Capella, 1993). Using facial electromyography (EMG), Dimberg (1997) demonstrated that viewing emotionally expressive faces generated facial changes corresponding to the emotions being viewed (happy faces generated increased activity in the zygomatic muscles while angry faces led to increased activity in the corrugator muscles) and that these changes occurred within several hundred milliseconds of viewing the stimulus. These results suggest that this level of emotional contagion is the result of a pre-wired neural process (Wild, Erb, & Bartels, 2001), with researchers hypothesizing that rapid reactions to emotional stimuli are mediated though the limbic regions of the brain (Le Doux, 1996; Whalen, et al, 1998; Holland & Gallagher, 1999). The facial reactions were accompanied by emotions, but the exact correspondence that was seen with the facial mimicry was occasionally absent. Instead, happy faces resulted in feelings of happiness but angry faces resulted in feelings of fear (Dimberg, 1988; Vaughan & Lanzetta, 1980).

Indeed, as evidenced above, emotional reactions do not always converge. For example, when in competition, people tend to display responses that diverge from those of their opponents, rather than converge (Lanzetta & Englis, 1989). When an opponent expressed joy during competition, the individual expressed distress. When an opponent expressed distress, the individual expressed joy. Similarly, when a player displayed a great deal of joy after scoring a goal in a soccer shootout, the next kick taken by an opponent was more likely to be missed than if the player was less exuberant (Moll, Jordet, & Pepping, 2010). The occurrence of emotional divergence is not limited to individuals in direct competition, but also includes individuals we see as dissimilar to ourselves or individuals we have negative attitudes towards. For example Likowski, Muhlberger, Seibt, Pauli, and Weyers (2008) found when there are preexisting

negative feelings towards another person, the mimicry of their happiness and sadness displays is diminished. Similarly, when another person is seen as an outgroup member, their emotional displays are less mimicked (Bourgeois & Hess, 2008). In short, responses to emotional displays vary with regard to the relationships between the individuals. People with opposing goals or from opposing groups may use emotional divergence to create more distance between them, while those with similar goals or from similar groups may use emotional convergence to bring them closer together.

The displayed emotion also has an influence on whether convergence or divergence occurs (and this relationship is mediated by the context of the interaction and the perception of the relationship with the other person). For example, displays of happiness usually result in emotional convergence, regardless of situation or relationship (with a previously discussed exception for direct competition) (Hess & Blairy, 2001). On the other hand, displays of anger or fear usually create divergent emotional expressions (Lundqvist & Dimberg, 1995; Dimberg & Ohman, 1996, van der Schalk et al., 2011).Because anger is presumably a signal of aggression or threat, individuals typically report reactions of fear when witnessing the anger displays of another (Lundqvist & Dimberg, 1995), with outgroup displays of anger generating a greater fear response than in-group displays of anger (van der Schalk, et al., 2011). Similarly, displays of fear can lead to divergent emotional responses, particularly when that fear is displayed by an outgroup member. Van der Schalk, et al. (2011) found that fear displays by an in-group member resulted in displays of fear or concern, while fear displays of an outgroup member resulted in displays of aversion or contempt.

While people seem universally *capable* of catching emotions from others, individuals do vary in terms of their tendencies to do so and the degree to which this happens. In terms of

reactions to emotional stimuli, women are both more facially expressive than men—displaying more motor mimicry when encountering the facial expressions of others (Kring & Gordon, 1998; Doherty, Orimoto, Singelis, Hatfield, & Hebb, 1995)—and more susceptible to consciously experiencing the emotions of others—reporting higher instances of overall emotional contagion in various contexts (Doherty, et al., 1995). Individual differences in susceptibility (or resistance) to emotional contagion arise from various factors including genetics, biological sex, personality, etc. Specifically, the following characteristics indicate a person is particularly likely to catch the emotions of others: being self-aware, being emotionally reactive, paying attention to others, seeing oneself as inter-related to others, being able to read other people's emotions, and mimicking others (Hatfield, Cacioppo, & Rapson, 1994). Individuals without these characteristics are more resistant to emotional contagion.

It is important to note, here, the similarities between pheromones and emotional contagion. As previously stated, a pheromone is a chemical secreted by an individual that produces a change in the sexual or social behavior of another individual of the same species. Similarly, emotional contagion occurs when "precipitating stimuli from one individual, act upon one or more other individuals, and yield corresponding or complementary emotions in these individuals" (Hatfield, Cacioppo, & Rapson, 1994, p. 5). As one can see, these two definitions are quite similar. In fact, I argue that one "precipitating stimulus" for emotional contagion is the chemical signals of others. In essence, pheromones act as a chemically induced emotional contagion. Because the process of emotional contagion can occur at either the conscious or subconscious levels (Neumann & Stack, 2000), pheromones and chemical communication seem to be ideal candidates for new avenues of exploring emotional contagion theory. As noted by Hatfield, Cacioppo, and Rapson (1993), "emotional contagion may prove useful in understanding

and perhaps advancing various areas of interpersonal communication—between lovers, between teachers and students, between parents and children, between therapists (or doctors or lawyers) and clients, between labor or international negotiators, between heads of state" (p. 99). Studies in emotional contagion have used a variety of media to "infect" participants with the emotions of others. Researchers have used direct interactions (Sullins, 1991; Gump & Kulik, 1997), pictures (Dimberg, 1988), and audio recordings (Hietanen, Surakka, & Linnankoski, 1998), but they have yet to use chemical stimuli to attempt to induce emotional contagion. Using our current understanding of chemical communication, it is my belief that exploring how humans communicate chemically will prove useful in understanding how more overt patterns of communication arise. In short, human odors are an interesting avenue for exploring human interaction and nonverbal communication and this project seeks to do just that. This project attempts to further our understanding of how human perceptions and human interactions might be influenced by the presence of human chemosignals in the form of apocrine sweat. The project consists of two studies. The first study attempts to understand the influences of apocrine sweat on perceptions of and reactions to a fear stimulus. The second study attempts to understand the influences of apocrine sweat on human interaction (in the form of a conflict discussion between romantic partners). The hypotheses and corresponding rationales of each study are outlined below.

Hypotheses

Study 1

The process of producing apocrine sweat has already been outlined above. However, as a brief refresher, unlike eccrine sweat glands (which are secreting sweat all the time) apocrine sweat glands only secrete sweat during times of stress. Previous research (Valenta & Rigby,

1968; Ackerl et al., 2002; Chen et al., 2006; Prehn et al., 2006; Prehn-Kristensen, et al., 2009; Zhou & Chen, 2009; de Groot et al., 2012) has shown that this particular type of sweat has particular influences on the human mind. Apocrine sweat has been shown to increase brain activity in areas associated with both fear and empathy (Prehn-Kristensen et al., 2009), to increase alert behaviors (scanning the room, blinking, respiration, etc.) in a neutral environment (Prehn et al., 2006; de Groot et al., 2012), and to increase the perception of fear in others (through rating ambiguous faces as more fearful) (Zhou & Chen, 2009). While it is not currently clear *how* or *why* these responses occur (through either an innate, instinctual mechanism, or a learned association), evidence shows that this particular kind of sweat is recognized by other people and responded to in distinct ways. In short, exposure to apocrine sweat (sweat which is only secreted in times of stress or fear) creates stress or fear responses in those exposed to it. Currently, research in this area has attempted to understand the emotional ramifications of apocrine sweat under non-emotional conditions. This study seeks to extend these findings by exploring the emotional effects of apocrine sweat when emotions are already likely to be in play. Because emotional contagion often results in the creation of convergent emotions in others (Hatfield, Cacioppo, & Rapson, 1994), chemically induced emotional contagion should have similar effects. Thus:

H1: Those exposed to fear chemosignals will rate a fear stimulus more frightening than those exposed to neutral odors

As previously discussed, women generally have a stronger, more developed olfactory system than men (Cain, 1982). Women can both more easily perceive odors in the environment and more accurately classify those odors (Doty & Cameron, 2009). Further, women often rely on their sense of smell for mating purposes more regularly than men (Wedekind et al, 1995; Franzoi

& Herzog, 1987; Herz & Cahill, 1997; Herz & Inzlicht, 2002). While men are able to detect ovulation, they primarily use that information (however subconscious it may be) to increase mating behaviors during the fertility window, *not* to select with whom to mate. Women, on the other hand, use olfactory information broadcast by others to make determinations about who would make the best mate (Franzoi & Herzog, 1987; Wedekind et al, 1995). Further, when asked to identify kinship based on scent, women generally perform better on this task than men (Porter & Moore, 1981; Porter, Cernoch, & Balogh, 1985). In short, women use the social communication function of their sense of smell more frequently than men. While this particular social function (mating decisions) is much different from the situation created in this study (fear reactions), the fact that women rely on their sense of smell more than men remains the same. Not only do women rely on their sense of smell more than men, they also have an all-around better sense of smell. Not only can they perceive an odor in the environment much more quickly than men, they are also able to determine the location and cause of that odor much more easily than men (Cameron, 2007). The combination of women's more developed olfactory system and women's increased reliance on the sense of smell in social situations implies that women will be more sensitive to the effects of apocrine sweat than will men. Therefore:

H2: Women will have stronger reactions to fear chemosignals than men.

As previously highlighted, emotional contagion is the ability to "feel with," rather than "feel for" another person. In other words, an increased susceptibility to emotional contagion is associated with an increased ability to put oneself in someone else's shoes. To not just *understand* where another person is coming from, but to actually *feel* where that person is coming from, by experiencing the same emotions they are experiencing. Emotional contagion is often characterized as a form of primitive empathy, or empathy that does not rely on the

individual "feeling for" someone of their own accord, but rather *causes* the individual to "feel with" the other person, by creating the same emotions in themselves. Thus, those who are more susceptible to emotional contagion are more likely to experience feelings which coincide with the feelings of another. Though these emotions are occasionally divergent, much of the time, emotional contagion creates convergent emotional responses, or emotional responses which match the emotions displayed by the person whose emotions are being "caught." If one displays sadness, those who are susceptible to emotional contagion will feel sad; if one displays fear, those who are susceptible to emotional contagion will feel fear; etc. Thus, if a person susceptible to emotional contagion were to watch another person during a stressful ordeal, that person would be more likely to experience stress themselves. Further, if the secretions of others serve as a chemical form of emotional contagion (by being a chemical signal relaying the stress of another), those who are more susceptible to emotional contagion *should* be more susceptible to chemical emotional contagion. These points result in the final two hypotheses for Study 1:

H3: Higher susceptibility to emotional contagion will be positively associated with reported experiences of fear.

H4: Those who are more susceptible to emotional contagion will have stronger reactions to fear chemosignals than those who are less susceptible to emotional contagion.

Study 2

A number of variables can influence the course of a conflict discussion between two people. For example, both music (Honeycutt & Eidenmuller, 2001) and lighting (Baron, Rea, & Daniels, 1992) have subconscious but observable influences on interpersonal conflicts. Additionally, a variety of nonverbal behaviors can influence the course of a conflict discussion. While previous research has focused on visual or auditory nonverbal behaviors during conflict (facial expressions, tone of voice, etc.), the present study focuses on olfactory influences of

interpersonal conflict. Study 2 explores the effects of apocrine sweat on behavior during a conflict discussion. There are a number of interesting possibilities for the effects of apocrine sweat in this situation, but this study will only focus on one primary effect: the amount of anger perceived or experienced during a relational conflict.

As has been previously discussed, apocrine sweat is only secreted during times of stress, and exposure to the apocrine sweat of another has perceivable effects on subsequent behaviors. Therefore, I will treat apocrine sweat as a chemical form of emotional contagion. Emotional contagion has been shown to have important effects on relationships (Goodman & Shippy, 2002; Bookwala & Schulz, 1996; Tower & Kasl, 1995). For example, married couples often come to share the same emotional states as one another—if one partner becomes depressed, the other partner soon exhibits greater symptoms of depression themselves (Bookwala & Schulz, 1996). Emotional contagion is usually more likely to occur if the couple reports being especially close to one another (Tower & Kasl, 1995), or if the couple reports relying on one another for social support (Goodman & Shippy, 2002). Thus, emotional contagion not only occurs in brief, one-of interactions, but also in long-term, steady relationships with repeated interactions.

In addition to emotional *contagion* being an important element in relationships, emotions *in general* are also extremely important factors in relationships, particularly the emotions exhibited during arguments or conflicts. Gottman, Levenson, and Woodin (2001) showed that the facial expressions of emotions conveyed during arguments were associated with a couple's long-term happiness and a couple's long-term success in the relationship. Particular emotional displays were actually associated with a greater chance of the relationship dissolving within three years of the study (Gottman, Levenson, & Woodin, 2001). Further, displays of anger or aggression have been shown to have long-term impacts on the individuals at which these

displays were directed (Caldwell, Krug, Carter, & Minzenberg, 2014; Capaldi & Owen, 2001; DeMaris & Swinford, 1996; Carlson, McNutt, Choi, & Rose, 2002). In fact, in heterosexual relationships where the male partner exhibited verbal or physical aggression toward his female partner, the female partner reported experiencing greater levels of fear of her partner, even years after the incident occurred (and with no subsequent incidents occurring in the meantime) (Gordis, Margolin, & Vickerman, 2005). Thus, heightened levels of aggression in one conflict can have long-lasting ramifications for each subsequent conflict.

While most people would not be overtly aware that one partner experiencing fear in a conflict discussion might have long-lasting negative effects on the rest of the relationship, many people may be intuitively aware that fear in a conflict discussion is a cause for concern. Further, previous work in emotional contagion shows that certain emotional expressions can sometimes result in divergent, rather than convergent emotions (Dimberg, 1988; Vaughan & Lanzetta, 1980). As such, sensing fear in one's partner may be negatively related to expressions of anger in a conflict. In other words, if one partner comes to suspect the other partner is currently afraid, that partner may become less angry in order to calm their partner down. They would not want their partner to be afraid of them, and so they would alter their behavior to lessen that response. If apocrine sweat is a nonverbal indicator of fear or stress, partners may assume that the presence of apocrine sweat during a conflict discussion is indicative of the presence of fear in their partner. Thus:

H1: Exposure to apocrine sweat during a conflict discussion will be associated with lower reported levels of anger during that discussion.

As far as expressing emotions goes, women are generally encouraged to express the entire range of their emotional experience, save for one: anger. Conversely, men are typically

encouraged to *suppress* their emotional experiences, with the primary exception of one emotion: once again, anger (Jansz, 2000; Kring & Gordon, 1998). Thus, while men are generally socialized to express anger or nothing at all, women are generally socialized to express anything *but* anger (Wester, Vogel, Pressly, & Heesacker, 2002; Brody & Hall, 2008). This difference in socialization holds true for a wide range of social situations—work, school, romantic relationships, friendships, etc. I expect these differences to appear in the current study. If women are socialized not to express their anger, and men are socialized *to* express their anger, there should be differences in the amount of anger/aggression expressed during a conflict discussion. Thus:

H2: Women will report lower levels of anger/aggression during a conflict discussion.

As outlined in the rationale for the third hypothesis of Study 1, women have a stronger sense of smell than men, and they also rely on that sense of smell in social situations more than men. If women have both a stronger sense of smell, and also use that sense to better navigate social situations; and if apocrine sweat serves to convey information about a social situation, it stands to reason that women will be more strongly affected by apocrine sweat than men. Therefore:

H3: The effects of apocrine sweat on anger/aggression during a conflict discussion will be stronger for women than for men.

As outlined in the rationale for Study 1, if the chemical secretions of others act as a source of emotional contagion, those who are more susceptible to emotional contagion should also be more susceptible to the effects of apocrine sweat. In order to avoid repeating information, I will refer you to the rationale for Study 1 for a more complete discussion of the potential links

between susceptibility to emotional contagion and apocrine sweat. Therefore, the final hypothesis for Study 2 is the same as the final hypothesis for Study 1:

> H4: Those who are more susceptible to emotional contagion will be more strongly affected by apocrine sweat than those who are less susceptible to emotional contagion.

CHAPTER THREE

STUDY ONE

While previous research supports the possibility that fear chemosignals influence human perceptions, this research is still rather sparse. Previous research has studied the effects of fear chemosignals on brain patterns and, in a limited capacity, on social cues (specifically, rating the emotions found in pictures of human faces). Study one seeks to examine the effects fear pheromones have on responses to a fear stimulus. Rather than judging a social cue (a non-anxiety-inducing stimulus) while under the effects of chemosignals, this study examines responses to an anxiety-inducing stimulus while being exposed to fear chemosignals. Based on the research outlined in Chapter 2, it is predicted that exposure to fear chemosignals will increase one's fear response. Specifically, Study 1 seeks to provide answers to the following hypotheses:

H1: Exposure to apocrine sweat will be positively associated with increased levels of fear.

H2: Susceptibility to emotional contagion will be positively associated with increased levels of fear.

H3: Women will have stronger reactions to apocrine sweat than men.

H4: Those who are more susceptible to emotional contagion will have stronger reactions to apocrine sweat than those who are less susceptible to emotional contagion.

Method

This study took place in two stages. In the first stage, participants were recruited to donate sweat for use in the main experiment. Through random assignment, donors either donated stress-related apocrine sweat, or heat-related thermoregulatory sweat. After sweat samples were collected, a new set of participants was recruited for the main experiment. Donation procedures, experimental procedures, and the instruments used to test the hypotheses are outlined in greater detail below.

Donation

Participants. Participants were university students from introductory communication courses that required participation in research for course credit. Students were recruited for either the donation phase of the experiment or the response phase of the experiment. Students were not permitted to participate in both phases. A total of 50 students participated in the donation phase of this project. There were 15 female and 35 male participants. They reported a mean age of 20.85 years (SD =2.79) and were primarily white (n=41, 82%). Other ethnicities included black (n=5, 10%) and Asian (n=2, 4%); 2 participants did not provide this information.

Procedures. Recruitment for the study took place via an online scheduling system where participants were allowed to select studies from a variety of research credit opportunities. Students enrolled in Communication Studies courses which required participation in department research were the only people permitted to participate in the study. Students received a small amount of research credit for their participation (1.5% of their grade). Data collected was anonymous (no identifying information was collected or linked to the participant's data). All students provided informed consent and procedures were approved by the Louisiana State University Institutional Review Board (see Appendix A).

Donors were asked to take a shower with unscented or low-odor soap the night before collection. They were instructed not to apply deodorant following the shower or on the day of the collection. They were also asked not to consume odorous foods (garlic, onions, etc.) the day before or the day of collection. They were asked upon arrival if they had followed each of these instructions. Those who failed to comply were granted credit for attending the session, but were excluded from the collection process. Participants were asked to tape cotton axillary pads under their arms using hypoallergenic surgical tape. Once affixed, participants answered a few brief

demographic questions. Following these procedures, participants viewed a short (~7 minutes) YouTube video of two men climbing a telephone tower (this video can be found at https://www.youtube.com/watch?v=BsiUdjF8psk). Following the video, participants filled out self-report measures about their personal levels of anxiety and fear during the clip. Axillary pads were collected, affixed to the inside of a surgical mask marked with a purple dot, and stored in an airtight container at -18° C in accordance with the accepted storage method of other, similar experiments (de Groot, Semin & Smeets, 2014; Zernecke et al., 2011; Zhou & Chen, 2009; Prehn-Kristensen et al., 2009).

The control group followed somewhat different procedures. After arriving at the lab, the control group taped cotton axillary pads to the small of their backs using hypoallergenic surgical tape. This location (small of the back) was selected to ensure that the thermoregulatory sweat was not contaminated with apocrine sweat. Because there is no way to guarantee that the participants in the thermoregulatory condition did not experience any stress prior to or during the collection process (thereby creating apocrine sweat in response to that stress), placing the axillary pads under the arms (where apocrine glands are at their highest concentration) would risk unnecessarily contaminating the samples. Additionally, similar research studies (de Groot, Semin & Smeets, 2014; Zernecke et al., 2011; Zhou & Chen, 2009; Prehn-Kristensen et al., 2009) use similar procedures for testing the effects of apocrine sweat. After affixing their cotton pads, participants answered questions concerning their demographic information. They stepped outside of the building and remained there until they began to sweat (the temperature was more than warm enough to induce a sweat-response in the donors). After perspiration began, they came back inside the building. Their axillary pads were then collected, affixed to the inside of a surgical mask marked with a gold dot, and stored in an airtight container at -18° C. To ensure the

sweat did not degrade in quality or potency over time or over multiple uses, axillary pads were used for one week and replaced by a new sample.

Experiment

Participants. Participants were university students from introductory communication courses that required participation in research for course credit. Students were recruited for either the donation phase of the experiment or the response phase of the experiment. Students were not permitted to participate in both phases. A total of 156 students participated in the experiment phase of this project. There were 81 female and 75 male participants. They reported a mean age of 20.58 years old (SD = 2.59) and were primarily white (n=117; 75%). Other ethnicities included black (n=26; 16%), Asian (n=4; 2%), Hispanic (n=3; 2%), and Native American (n=5; 3%).

Instrumentation. Several measures were used during the course of this study. These instruments included the Emotional Contagion Scale (Doherty, 1997), the Fear Survey Schedule (Wolpe & Lang, 1964), a version of Izzard's (1972) Discrete Emotions Scale that was modified to assess fear, and a questionnaire assessing the participant's physical fear responses. Each of these instruments will be briefly discussed below. The complete scales can be found in Appendix B.

The Emotional Contagion Scale is a 15-item unidimensional measure which assesses a respondent's susceptibility to catching the emotions of others. The survey measures susceptibility to emotional contagion by assessing participant's responses to encountering someone displaying one of the basic, cross-culturally universal emotions (happiness, sadness, fear, anger, and love) (Ekman, 1992, Doherty, 1997). The measure uses a 5-point scale, where 1=never, 2=rarely, 3=sometimes, 4=usually, and 5=always. Past studies have examined

emotional contagion in light of several measures to which it should be logically related. Emotional contagion has been shown to be positively related to reactivity to social situations, emotionality, sensitivity to others, and empathy (Doherty, 1997; Lundqvist, 2006), while it is negatively related to emotional stability and alienation from others (Doherty, 1997). While some (Bhullar & Bains, 2013) argue that the Emotional Contagion Scale should be treated as a multidimensional model, Doherty (1997) argues that while items may load onto two factors (positive and negative emotions), a unidimensional model is most appropriate for the sake of parsimony. This project followed the advice of Doherty (1997) and treated the emotional contagion scale as a unidimensional measure. For Study 1, the Emotional Contagion Scale had an alpha reliability of 0.76, making it an acceptably reliable instrument. The mean was 3.65 and the standard deviation was 0.47.

Developed by Wolpe and Lang (1972), the Fear Survey Schedule is a 52-item instrument that measures the respondent's fear of a variety of objects or situations. In the Fear Survey Schedule, items are rated on a 1-5 scale in terms of how much the respondent is "disturbed by it nowadays", with 1 being not at all, 2 being a little, 3 being a fair amount, 4 being much, and 5 being very much. When initially conceived, the instrument was divided into six factors (animal fears, social or interpersonal fears, fear of tissue damage, fear of noises, classic phobias, and miscellaneous). For this study, participants completed the entire Fear Survey Schedule, but this analysis made particular use of the items measuring fear of heights. There were four items which corresponded to fear of heights (falling from a great height, falling from a small height, heights, and traveling in an airplane), which were combined to create an overall "fear of heights" measure (α=0.80). The mean for this measure was 2.46 and the standard deviation was 0.94

Izzard's Discrete Emotions Scale (1972), asks participants to assess which emotions they are experiencing in terms of multiple emotion adjectives (For example, "I feel excited," or "I feel nervous."). It is meant to simply assess which emotions the participant claims to have experienced, and uses multiple emotion adjectives in order to do so. This analysis used two adapted version of the Discrete Emotions Scale which focused primarily on the emotion of fear. In the first scale, participants were asked to respond to a range of statements assessing the amount of fear they themselves experienced ("I felt nervous," I felt apprehensive," I felt tense," "I felt scared," etc.). Items were scored using a 1-10 scale with 1 being the lowest amount of agreement with the statement and 10 being the highest amount of agreement with the statement. The 10-point scale was used as opposed to the more traditional 5-point scale because small differences in fear responses were thought to be more easily captured with this higher amount of granularity. The first scale had an alpha-reliability of 0.90, a mean of 4.72 and a standard deviation of 2.23. The second adapted scale was almost identical to the first, but this scale assessed the amount of fear the respondents thought *others* would experience, rather than the amount of fear they themselves experienced (For example, "Most people would feel nervous while watching this video," "Most people would feel apprehensive while watching this video," etc.). This scale had an alpha-reliability of 0.86, a mean of 5.48, and a standard deviation of 2.13.

I created a final set of questions assessing the amount of physical fear reactions participants experienced during the experiment. Physical fear reactions include things like sweaty palms, tense muscles, and breathlessness. Participants were asked to rate (on a 1-5 scale) whether or not they experienced any of a range of common physical reactions to fear. A Principle Components Analysis (PCA) with varimax rotation and an extraction criteria of an

eigenvalue >1 showed that the nine items loaded onto a single factor (Eigenvalue=4.37) and each of the factor loadings was above 0.60.Further, Cronbach's alpha was 0.89, showing this measure to be a reliable measure of physical fear reactions. The mean of this scale was 2.00 with a standard deviation of 0.77.

Procedures. The experiment took place inside a lab space designed to look more like a room in someone's home than a laboratory. It contained a couch, a table and chairs, fake potted plants, and generic paintings on the wall. There was also a small desk with a computer on it. To prepare for the experiment, one surgical mask containing apocrine sweat and one surgical mask containing thermoregulatory sweat were placed inside separate airtight, glass containers and brought to room temperature. The two air-tight containers holding the masks were placed on a table inside the lab where the experiment was to take place. Each container held a single surgical mask and each container was marked with either a purple dot (for the apocrine sweat condition) or a gold dot (for the thermoregulatory sweat condition).

After arriving in the lab, participants were asked to complete two pretest measures. These measures included the Emotional Contagion Scale (a 15-item scale assessing one's susceptibility to emotional contagion) and the Fear Survey Schedule (a 52-item survey assessing one's responses to common fears). For the complete scales, see Appendix B. After the pretest measures were completed, instructions for the next part of the study were read. The instructions were read prior to random assignment in order to avoid problems with subconscious experimenter expectancy effects. After instructions were given, the experimenter left the room to observe, and the participant flipped a coin. The results of this coin toss determined in which condition the participant would be (apocrine sweat or thermoregulatory sweat). After the coin toss, the participant opened the corresponding air-tight container and removed the surgical mask. They

placed the mask over their nose and proceeded to watch the same video used during the collection phase. This ~7 minute video was taken with a camera attached to the helmet of a maintenance worker who was climbing a telephone tower. Fifty-two percent of the participants (n=82) were in the apocrine sweat condition, while 48% of the participants (n=74) were in the thermoregulatory sweat condition. The difference in participants in each group was a result of random assignment.

Following the video, participants rated their reactions to the video. These measures assessed the participants' psychological responses to the video, their physical responses to the video, and their predictions for how others might react to the video. For the complete scales, see Appendix B. The next section reports the relevant results of this study.

Results

To test the hypotheses presented for this study, three different measures of fear were taken: self-reported psychological fear (i.e. "I was nervous," "I was apprehensive," "I was fearful," "I was excited," etc.), perceived responses others would have to the stimulus (i.e. "Most people would feel scared watching this video," "Most people would feel nervous watching this video," "Most people would feel excited watching this video," etc.), and self-reported physical reactions (i.e., "I felt butterflies in my stomach," "My palms started to sweat," "The bottoms of my feet started to tingle," "I felt like my heart was pounding," etc.). A confirmatory factor analysis (CFA) with an extraction criteria of an eigenvalue >1 was performed on the three dependent variables. Results of this analysis yielded three factors which met the extraction criteria (eigenvalues were 8.97, 1.41, and 1.08). Factor loadings were all in the acceptable range. Thus, the three factors were retained for this study. Bivariate correlations between all variables are presented in Table 3.1. The correlation table shows that the three measures of fear (psychological fear, physical fear, and predicted fear) are intercorrelated. It also shows several

correlations between the variables of interest. These relationships will be further explored with additional analyses. Difference of means tests and multivariate regressions with control variables were used to judge the relationship between exposure to fear chemosignals and experiences of fear. The results of these tests are outlined below.

Table 3.1. Bivariate Correlations for Study 1 Variables

	1	2	3	4	5	6	7
1. Psychological fear	---						
2. Physical fear	0.78***	---					
3. Predicted fear	0.75***	0.63***	---				
4. Type of sweat	0.42***	0.25**	0.20*	---			
5. Sex	0.07	0.03	0.03	−0.09	---		
6. Emotional contagion	0.16	0.23**	0.17*	−0.12	0.37***	---	
7. Fear of heights	0.25**	0.23**	0.04	0.10	0.38***	0.31**	---

*p<0.05, **p<0.01, ***p<0.001

This study's hypotheses concern the independent and interactive effects of type of sweat (thermoregulatory or apocrine), biological sex, susceptibility to emotional contagion, and fear of heights on different measures of fear. Hierarchical regression analyses were employed to test these hypotheses. A two-step regression equation was estimated for each measure of fear (psychological fear, physical fear, and the predicted fear of others). The main effects of type of sweat, biological sex, emotional contagion, and fear of heights were entered in the first step, and the products of both sweat and biological sex and sweat and emotional contagion (representing the two-way interactions between these variables) were entered in the second step. Organizing the analyses in this way allows one to account for previous effects, thus demonstrating the true contribution of interaction variables.

The first analysis used a 5-item self-reported psychological fear measure (α=0.90) as the dependent variable. The original instrument contained additional items assessing other emotional responses (guilt, joy, pride, etc.), but as these emotions were not included in my hypotheses, they

were excluded from this analysis. A two-sample difference of means test revealed a significant difference between the two groups ($t=6.343$, $df=154$, $p<0.0001$). The mean score of self-reported psychological fear in the thermoregulatory sweat group was 3.65 (SD=1.843) on a 10-point scale. The mean score of self-reported psychological fear in the apocrine sweat group was 5.68 (SD=2.13). These results show that exposure to apocrine sweat results in a 2.03 unit increase in self-reported experiences of fear over thermoregulatory sweat.

In order to account for the influence of additional factors, a two-step multivariate OLS regression model was estimated. A full breakdown of this analysis can be found in Table 3.2. The variables included in the first block were type of sweat, biological sex, susceptibility to emotional contagion, and the participant's pre-existing fear of heights.. These variables accounted for approximately 26% of the total variance in ratings of psychological fear ($R^2=0.26$, $F_{4, 147}=15.06$, $p<0.0001$). The effects for type of sweat, susceptibility to emotional contagion, and fear of heights were all significant at the 0.05 level. The positive coefficient for type of sweat indicates that exposure to apocrine sweat significantly increased psychological fear responses when compared to exposure to thermoregulatory sweat ($b=2.06$, $\beta=0.46$, $p<0.01$). Thus Hypothesis 1 was supported by this model. Similarly, the positive coefficient for emotional contagion ($b=0.86$, $\beta=0.18$, $p<0.01$) indicates that an increase in susceptibility to emotional contagion is associated with an increase in psychological fear response. Therefore, Hypothesis 2 was supported. Finally, the positive coefficient for fear of heights ($b=0.29$, $\beta=0.12$, $p<0.05$) indicates that as fear of heights increases, so too does psychological fear response to the stimulus. The coefficient for biological sex was not significant ($b=-0.07$, $\beta=-0.02$, $p>0.05$), indicating that males and females did not differ significantly on their psychological fear responses.

Table 3.2. Two-Step OLS Regression Estimates for Psychological Fear Responses.

Dependent Variable	Block 1--Main			Block 2—Interactions		
	Variable	b	β	Variable	b	β
Psychological Fear	Sweat	2.06***	0.46	Sweat x Gender	1.81***	0.35
	Gender	−0.07	−0.02	Sweat x Contagion	−0.54	−0.44
	Emotional Contagion	0.86***	0.18			
	Heights	0.29**	0.12			
	R^2	0.26		R^2	0.30	
	F	15.06***		F	13.65***	
				R^2 Change	0.04	
				F Change	3.69**	

*p<0.05, **p<0.01, ***p<0.001

In order to account for the unique contributions of the proposed interaction effects found in Hypothesis 3 and Hypothesis 4, a second block of variables was added to the original model. The variables added to the second block were the product of type of sweat and biological sex (representing the interaction between type of sweat and sex) and the product of type of sweat and susceptibility to emotional contagion (representing the interaction between type of sweat and susceptibility to emotional contagion). The additional variables included in the second block increased the R^2 value to 0.30 ($F_{6, 145}$=13.65, p<0.01), meaning the combination of variables accounted for approximately 30% of the variance in psychological fear reactions. The change in R^2 from Block 1 to Block 2 was 0.04 or 4% of the total variance accounted for by the model. Post hoc tests reveal that this change was statistically significant ($F_{2, 145}$=3.69, p<0.05). Thus, at least one of the included interaction effects had a statistically significant influence on the overall model. The interaction between sweat and biological sex was a significant predictor of psychological fear response (b=1.81, β=0.35, p<0.01), indicating that the psychological fear responses of women were more greatly affected by exposure to apocrine sweat than were the

psychological fear responses of men. Thus, Hypothesis 3 was supported. A visual representation of this relationship can be found in Figure 3.1. The non-significant interaction between type of sweat and susceptibility to emotional contagion ($b=-0.54$, $\beta=-0.44$, $p>0.05$) suggests that the effects of apocrine sweat were not stronger for different levels of emotional contagion. Instead, the evidence suggests that the effects of apocrine sweat were relatively equal regardless of how susceptible one is to emotional contagion under other circumstances. Thus, Hypothesis 4 was not supported by this model.

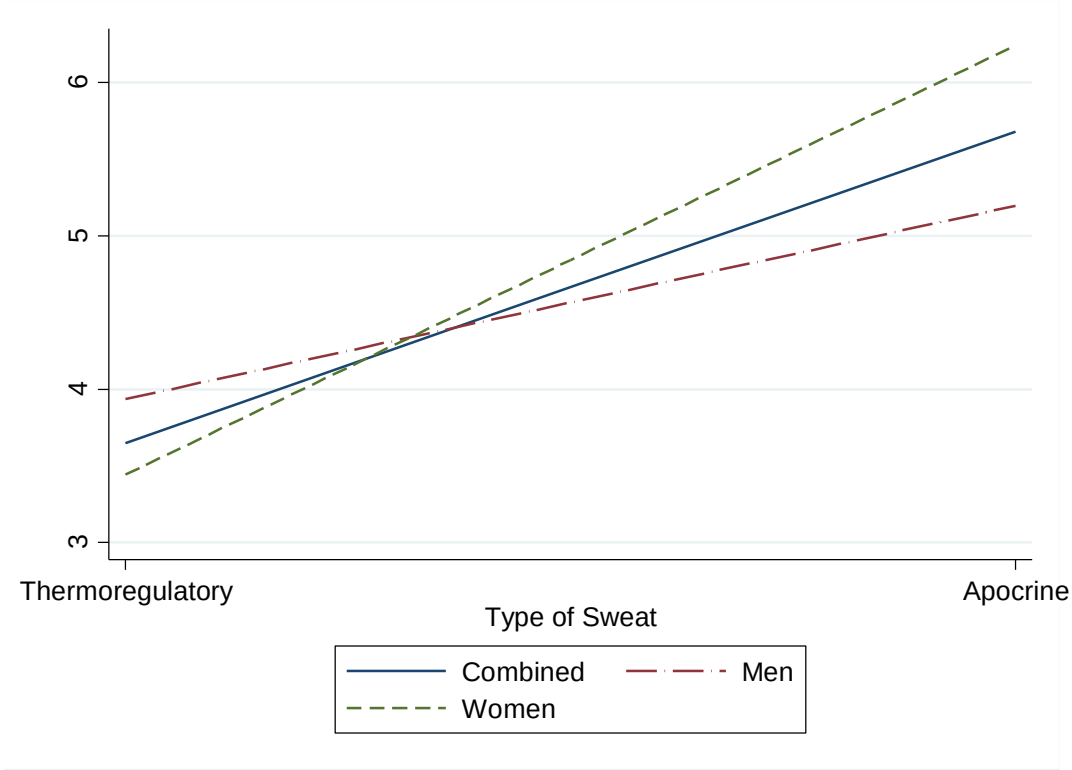

Figure 3.1. Psychological Fear Responses by Type of Sweat and Gender

The second analysis used a 9-item self-reported measure of physical fear responses ($\alpha=0.89$). This measure asked participants to what degree they experienced typical physical responses to fear or anxiety (these responses included things like butterflies in the stomach, shortness of breath, increased heartrate, etc.). These items were combined into a single scale assessing physical fear responses to the stimulus. A two-sample difference of means test was

conducted to determine if mean scores of physical fear responses were different for those exposed to apocrine sweat versus those exposed to thermoregulatory sweat. The results of the test were significant and in the hypothesized direction ($t=3.27$, $df=147$, $p=0.0007$). The mean score of physical fear response for those in the thermoregulatory sweat condition was 1.85 on a 4-point scale (SD=0.72) while the mean score of physical fear response for those in the apocrine sweat condition was 2.25 on a 4-point scale (SD=0.79). These results show that exposure to apocrine sweat resulted in a 0.40 unit increase in physical fear responses when compared to exposure to thermoregulatory sweat.

Next, a two-step multivariate OLS regression model was estimated. Results for this analysis can be found in Table 3.3. The variables included in the first block were type of sweat, susceptibility to emotional contagion, biological sex, and fear of heights. These variables yielded an R^2 of 0.14 ($F_{4, 140}=6.03$, $p<0.001$), thus accounting for approximately 14% of the variance in physical fear responses. The effects for type of sweat and susceptibility to emotional contagion were significant at the 0.05 level. The positive coefficient for type of sweat indicates that exposure to apocrine sweat significantly increased physical fear responses when compared to exposure to thermoregulatory sweat ($b=0.41$, $\beta=0.26$, $p<0.01$). Thus, Hypothesis 1 was supported by this model. Similarly, the positive coefficient for emotional contagion ($b=0.36$, $\beta=0.22$, $p<0.01$) indicates that an increase in susceptibility to emotional contagion is associated with an increase in physical fear responses. Therefore, Hypothesis 2 was supported. The coefficient for biological sex was not significant ($b=-0.08$, $\beta=-0.05$, $p>0.05$), indicating that males and females did not differ significantly on their physical fear responses.

Table 3.3. Two-Step OLS Regression Estimates for Physical Fear Responses.

Physical Fear	Sweat	0.41***	0.26	Sweat x Gender	0.56**	0.32
	Gender	−0.08	−0.05	Sweat x Contagion	−0.39*	−0.92
	Emotional Contagion	0.36***	0.22			
	Heights	0.11*	0.14			
	R^2	0.14		R^2	0.17	
	F	6.03***		F	6.87***	
				R^2 Change	0.03	
				F Change	2.68**	

*p<0.05, **p<0.01, ***p<0.001

In order to account for the unique contributions of the proposed interaction effects found in Hypothesis 3 and Hypothesis 4, a second block of variables was added to the original model. The second block of this analysis included the product of type of sweat and biological sex (representing the interaction between type of sweat and sex) and the product of type of sweat and susceptibility to emotional contagion (representing the interaction between type of sweat and susceptibility to emotional contagion). The additional variables included in the second block increased the R^2 value to 0.17 ($F_{2, 138}$=6.77, p<0.01), meaning the combination of variables accounted for approximately 17% of the variance in psychological fear reactions. The change in R^2 from Block 1 to Block 2 was 0.03 or 3% of the total variance accounted for by the model. Post hoc tests reveal that this change was statistically significant ($F_{2, 128}$=3.68, p=0.05), which indicates that at least one interaction variable was a significant contributor to the overall model. Upon further examination of the results, it became evident that the significant interaction variable was the product of type of sweat and biological sex (b=0.56, β=0.32, p<0.05), thus indicating that the physical fear responses of women were more greatly affected by exposure to apocrine sweat than were the physical fear responses of men. Thus, Hypothesis 3 was supported. A visual representation of this relationship can be found in Figure 3.2. The non-significant

interaction between type of sweat and susceptibility to emotional contagion (b=−0.39, β=−0.92, p>0.05) suggests that the effects of apocrine sweat were not stronger for different levels of emotional contagion. Instead, the evidence suggests that the effects of apocrine sweat were relatively equal regardless of how susceptible one is to emotional contagion under other circumstances. Thus, Hypothesis 4 was not supported by this model.

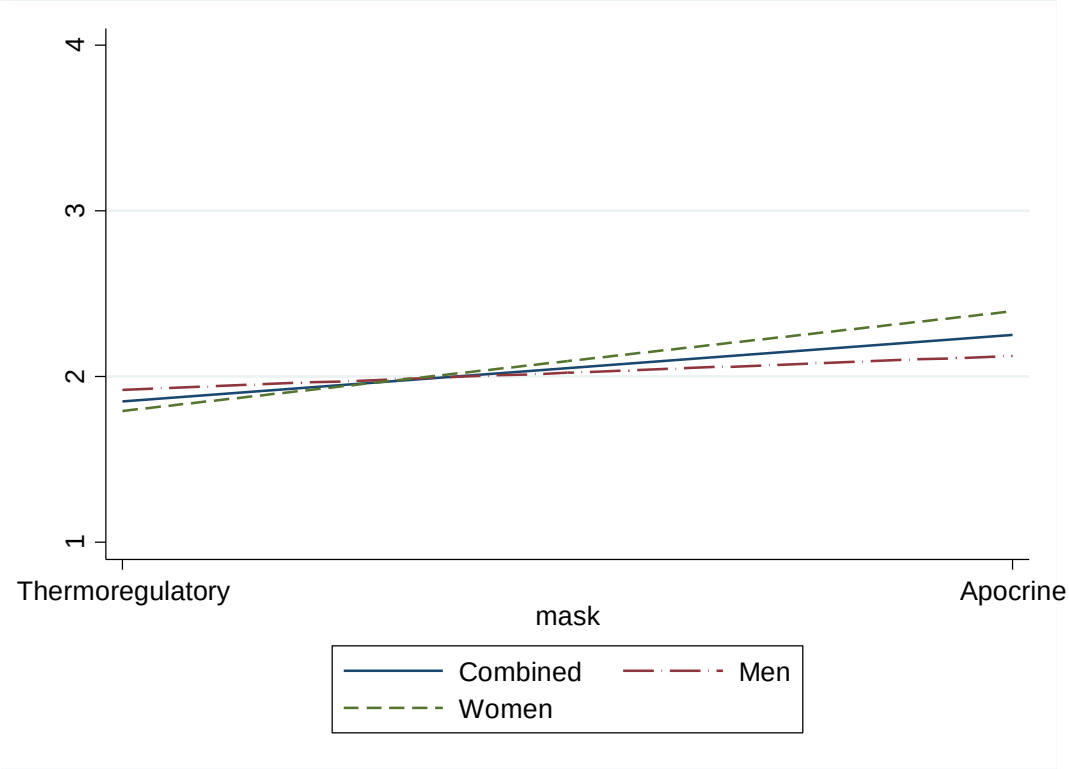

Figure 3.2. Physical Fear Responses by Type of Sweat and Gender

The third analysis used a 5-item assessment of the predicted responses of others to the fear stimulus (α=0.86) as the dependent variable. This measurement asked how the participant thought the typical person would react to watching the video in question. The measurement originally included additional items asking about other emotional responses, but as these responses were not part of any hypotheses they were excluded from this analysis.

First, a two-sample difference of means test was performed to determine if exposure to apocrine sweat increased the predicted fear responses of others. The results of this test were significant and in the hypothesized direction ($t=2.39$, $df=152$, $p=0.009$). The mean score for the predicted fear responses of others for those in the thermoregulatory sweat condition was 5.07 ($SD=2.12$) on a 10-point scale, while the mean score for predicted fear response for those in the apocrine sweat condition was 5.88 ($SD=2.08$) on a 10-point scale. Exposure to apocrine sweat resulted in a 0.81 unit increase in predicted fear response of others over exposure to thermoregulatory sweat.

Next a two-step multivariate OLS regression model was estimated. The results of this analysis are summarized in Table 3.4. The first block variables for this model were type of sweat, susceptibility to emotional contagion, biological sex, and fear of heights. These variables accounted for approximately 8% of the total variance in ratings of predicted fear ($R^2=0.08$, $F_{4, 145}=3.32$, $p<0.05$). The effects for type of sweat and susceptibility to emotional contagion were significant at the 0.05 level. The positive coefficient for type of sweat indicates that exposure to apocrine sweat significantly increased predicted fear responses when compared to exposure to thermoregulatory sweat ($b=0.98$, $\beta=0.23$, $p<0.01$). Thus, Hypothesis 1 was supported by this model. Similarly, the positive coefficient for emotional contagion ($b=0.97$, $\beta=0.21$, $p<0.01$) indicates that an increase in susceptibility to emotional contagion is associated with an increase in predicted fear responses. Therefore, Hypothesis 2 was supported. The coefficient for biological sex was not significant ($b=-0.18$, $\beta=-0.04$, $p>0.05$), indicating that males and females did not differ significantly on their predicted fear responses.

Table 3.4. Two-Step OLS Regression Estimates for Predicted Fear Responses.

Predicted Fear	Sweat	0.98***	0.23	Sweat x Gender	1.10**	0.22
	Gender	−0.18	−0.04	Sweat x Contagion	0.01	0.01
	Emotional Contagion	0.97***	0.21			
	Heights	−0.04	−0.02			
	R^2	0.08		R^2	0.10	
	F	3.32***		F	3.06	
				R^2 Change	0.02	
				F Change	1.39	

*p<0.05, **p<0.01, ***p<0.001

The second block of this analysis included the product of type of sweat and biological sex, and the product of type of sweat and emotional contagion. The additional variables included in the second block drove the R^2 value to 0.10 ($F_{6, 143}$=3.06, p<0.01), meaning the combination of variables accounted for approximately 10% of the variance in psychological fear reactions. The change in R^2 from Block 1 to Block 2 was 0.02, or 2% of the total variance accounted for by the model. Post hoc tests reveal that this change was not statistically significant ($F_{2, 143}$=1.39, p>0.05), which indicates that the interaction variables were not significant contributors to the overall model (thus, Hypotheses 3 & 4 were not supported by this analysis).

After reviewing the results of these three analyses, one can conclude that there is full support for Hypotheses 1 & 2 (fear responses increase in response to both exposure to apocrine sweat and increased susceptibility to emotional contagion), there is partial support for Hypothesis 3 (reactions to apocrine sweat are stronger for women for 2 out of 3 measures of fear), and there is no support for Hypothesis 4 (reactions to apocrine sweat are similar for all levels of emotional contagion). The results of these four hypotheses are discussed in further detail below.

Discussion

The results outlined above contain interesting revelations about the effects of apocrine sweat on human perceptions. This study examined the effects of apocrine sweat on three measures of fear (self-reported psychological fear, self-reported physical fear responses, and the predicted fear responses of others upon viewing the same stimulus). The effects of biological sex and susceptibility to emotional contagion were also examined, with a particular interest in the interaction between apocrine sweat and these two variables. In this section, the results outlined above will be discussed in further detail.

Apocrine Sweat

The first part of this discussion section will focus on the effects of apocrine sweat as observed in the preceding study. These effects were hypothesized to be positively associated with increases in fear as captured by the measures employed in the study. The effects of apocrine sweat on fear and the interaction between apocrine sweat and biological sex will be discussed below.

Effects on Fear. As hypothesized, exposure to apocrine sweat was significantly associated with increases in levels of fear for all three measures recorded for this study. For psychological fear, exposure to apocrine sweat was associated with a 2.07 unit increase in fear reactions. In laymen's terms, if an individual rated a fear stimulus as a 5 on a scale from 1-10 scale after being exposed to thermoregulatory sweat, that individual would rate the same fear stimulus around a 7 after being exposed to apocrine sweat. This effect held true even after controlling for the effects of biological sex, susceptibility to emotional contagion, and fear of heights.

Not only were people exposed to apocrine sweat mentally more frightened by the stimulus, they also reported higher levels of physical fear reactions than their thermoregulatory counterparts. This finding demonstrates that an increased level of fear after exposure to apocrine sweat is not something individuals simply *think* they perceive. Instead, the responses of their bodies indicate that they actually *are* experiencing more fear than those exposed to thermoregulatory sweat. While physical fear responses were measured using self-report data (a major caveat to the previous point), that does not entirely undermine the idea that the reported physical fear reactions are very telling indicators of actual fear. For instance, it is relatively easy for one to convince oneself that they were very scared after watching something scary, even if they were not actually that scared while it was happening. However, it is somewhat more difficult to convince oneself that the palms of one's hands were extremely sweaty, even when they were not sweaty at all. In this regard, the increase in physical fear reactions after exposure to apocrine sweat is a very important piece of the overall apocrine sweat puzzle. Naturally, future research might include physiological measures (such as blood pressure, heart-rate, and galvanic skin response) in order to confirm these initial results.

The increase in the predicted fear responses of others after exposure to apocrine sweat is another interesting element of this study. Not only do people exposed to apocrine sweat report experiencing more fear themselves, they also expect *others* to experience more fear in response to the same stimulus. This offers evidence that apocrine sweat alters overall perceptions of the stimulus, in addition to simply altering the individual's reactions to that stimulus. Indeed, this and the other two findings outlined above offer support for the idea that chemical communication can and does influence the perceptions and emotional experiences of other individuals.

Previous research in this area has exclusively focused on either neurological reactions to apocrine sweat, or the effects of apocrine sweat under neutral or ambiguous conditions. The present study advances our understanding of the effects of apocrine sweat on human perceptions by testing its effects under non-neutral conditions, specifically, under a fear condition. Instead of asking participants to rate how frightening a neutral or ambiguous image was, this study asked participants to rate how frightening an already frightening stimulus was. Further, this study used a video rather than a still photograph as is typically used during studies of this nature. Expanding the conditions to include a frightening moving image, rather than an ambiguous or neutral still image, provides us with a better understanding of the influences of apocrine sweat on human perceptions. Previous research has focused on neutral or ambiguous stimuli seemingly in order to maximize the potential effects of the apocrine sweat; however, this study demonstrates that strong effects are still found under non-neutral conditions. Obviously, directly comparing results from separate studies is not a valid determination of the relative effects of each study; however, the strong effects of this study certainly warrant future research to determine under which conditions apocrine sweat has the most potency.

Interaction with biological sex. As hypothesized, apocrine sweat affected men and women differently in terms of their fear reactions to the fear stimulus. After controlling for the effects of the other variables, apocrine sweat had a stronger effect on women's psychological fear responses, physical fear reactions, and predictions of the fear responses of others than it did on men's. The more sensitive and more developed olfactory system of women makes this finding interesting, but not surprising. If women generally perceive, interpret, and respond to olfactory cues more than men, it makes complete sense that apocrine sweat would have a stronger effect on women than it does on men. In fact, previous research in the area of chemical communication

has exposed exclusively female participants to exclusively male sweat (Wedekind et al., 1995). This choice was made for two reasons: first, men generally have a stronger, more pungent body odor than women (as discussed in Chapter 2, this is because men generally host more *coryneform* bacteria, which is known to produce a stronger odor than the *coccal* bacteria more commonly found on women); second, women are generally more sensitive to all odorants, so by extension, they should be more sensitive to the sweat of others. However, just because they are able to more easily *perceive* these odors, does not necessarily mean that they are more strongly *influenced* by them. The results of this study, while offering nothing to support the idea that women perceive odors more easily, does offer support that women are more strongly *influenced* by the odors of others. After controlling for the effects of emotional contagion and fear of heights, the interaction models presented in this study indicate that women experience stronger reactions to apocrine sweat than men. Next, the effects of emotional contagion on fear (and the interaction between apocrine sweat and emotional contagion) will be further discussed.

Emotional Contagion

The second part of this section will focus on the effects of emotional contagion which were observed in the preceding study. Emotional contagion was hypothesized to be positively associated with increases in fear as captured by the measures used in this study. Additionally the interaction between emotional contagion and apocrine sweat will be discussed in this section.

Effects on Fear. The results of this study demonstrate that susceptibility to emotional contagion is significantly associated with perceived experiences of fear. As described in Chapter 2, emotional contagion is the ability to "feel with" another person, rather than "feel for" that person. Those who are more susceptible to emotional contagion are more likely to "feel with" an individual they encounter. The results of this analysis demonstrate that this is certainly the case

here. Individuals who were more susceptible to emotional contagion were much more likely to "feel with" the individual they were watching, thereby experiencing fear as though they themselves were climbing the telephone tower. Even after controlling for the effects of type of sweat, biological sex, and fear of heights, those who were more prone to experiencing emotional contagion were more likely to report experiencing higher levels of fear than those who were less prone to catching the emotions of others. These people were also more likely to report increased physical fear responses (sweaty palms, tense muscles, etc.) than others *and* they were more likely to expect other people to feel the same way in response to the stimulus. Thus, the expected link between susceptibility to emotional contagion and increased fear responses was found in this study.

This study provides further evidence that those who score higher on emotional contagion experience greater emotional responses to the emotional stimuli of others than those who score lower on emotional contagion., This finding contributes to our overall understanding of emotional contagion, as well as to our understanding of chemical emotional contagion. Increases in emotional contagion were associated with increases in fear, regardless of the type of sweat participants were exposed to. Further, stress-induced apocrine sweat contributed to increased fear responses, regardless of the individual participant's susceptibility to emotional contagion. In other words, the findings concerning emotional contagion and apocrine sweat may suggest that these two phenomena occur via separate mechanisms. This possibility will be discussed in greater detail when I examine the interaction between emotional contagion and apocrine sweat below.

Interaction with apocrine sweat. Evidence for the hypothesized relationship between susceptibility to emotional contagion and susceptibility to apocrine sweat was absent in this

study. The original hypothesis argued that if apocrine sweat really was a chemical form of emotional contagion, those who were more sensitive to emotional contagion should also be more sensitive to apocrine sweat. However, support for this interaction was entirely absent. The effects of apocrine sweat were not different for different levels of emotional contagion. Instead, the effects seemed to be equal across all levels of emotional contagion. Because no previous studies have examined the interaction between susceptibility to emotional contagion and stress-induced apocrine sweat, I cannot say if this finding is in line with previous research or not. However, it is possible that using an already emotionally valenced stimulus (rather than a neutral or ambiguous stimulus as in previous studies) is at least partially responsible for the lack of a significant interaction. This study shows that, while fear *was* present in the thermoregulatory condition, it was *greater* for those in the apocrine condition. Studies using ambiguous or neutral stimuli demonstrate that fear is *only* present in the apocrine sweat condition, not in the thermoregulatory condition. Thus, perhaps apocrine sweat has equal effects on fear for different levels of emotional contagion when the stimulus is already emotionally valenced, but would have different effects for levels of emotional contagion when the stimulus is neutral or ambiguous. A future study might examine the effects of apocrine sweat on both neutral/ambiguous stimuli and emotionally valenced stimuli in order to determine if the interaction between emotional contagion and apocrine sweat exists in more neutral situations, but not in already emotional ones.

A further explanation for the lack of interaction might be found in the olfactory system itself. As previously mentioned, the olfactory system is the only sensory system that completely bypasses the thalamus on its way to the brain. The thalamus is responsible for higher-level processing of stimuli, deciding what information is important and should be attended to, and what information is generally background noise and can be ignored. While much of the process

of emotional contagion is automatic and subconscious, it is *still* filtered through the thalamus (Nummenmaa, Hirvonen, Parkkola, & Hietanen, 2008). Thus, the thalamus may be helping to decide what emotional cues from others are important and should receive further processing, and what emotional cues from others are unimportant and should therefore be put aside in favor of something more interesting. Those who are more susceptible to emotional contagion may have a thalamus that places greater importance on a larger number of the emotional cues of others, while those who are less susceptible to emotional contagion may have a thalamus that places less importance on those same emotional cues. Because the olfactory system *bypasses* the thalamus, there is not a chance for this part of the brain to decide if a chemosignal is important or not, which means that susceptibility to emotional contagion would *not* influence the effects of apocrine sweat. Thus, while emotional contagion is sometimes called "primitive empathy," the fact that chemical signals bypass the parts of the brain that are (at least partially) responsible for creating empathy might mean that chemical emotional contagion can be thought of as an even more "primitive" form of "primitive empathy." This "primitive-plus" version of chemical emotional contagion is further supported by the fact that the processing of chemosignals (such as pheromones) has evolved in *all* phyla of the animal kingdom, making it the oldest phylogenetic system shared by *all* organisms (Hildebrand & Shepherd, 1997). In other words, the olfactory system is one of our most primitive senses, meaning that emotional contagion taking place via the olfactory system would be the most primitive form of emotional contagion available to us.

CHAPTER FOUR

STUDY TWO

If fear chemosignals have an influence on our experiences and perceptions (as demonstrated in Study 1), what influence might they have on our everyday interactions? Study Two seeks to examine how apocrine sweat influences the amount of anger displayed during a discussion of a relational conflict. Specifically, this study seeks to provide answers to the following hypotheses (outlined in greater detail in Chapter 2):

H1: Exposure to apocrine sweat during a conflict discussion will be associated with lower levels of anger during that conflict.

H2: Women will display lower levels of anger during a conflict discussion.

H3: The effects of apocrine sweat on anger during a conflict discussion will be stronger for women than for men.

H4: The effects of apocrine sweat on anger during a conflict discussion will be stronger for those who are more susceptible to emotional contagion than those who are less susceptible to emotional contagion.

Method

Donation

Donation methods for this study were identical to the methods used in Study 1. Therefore, they will not be rewritten here. For a review, see the Methods section of Study 1.

Experiment

Participants. Participants were university students who were currently in a romantic relationship and enrolled in introductory CMST courses that required participation in research for course credit. Participants were asked to bring their significant other with them to the lab for this study. Those who could not bring their significant other were not permitted to participate.

Students were recruited for either the donation phase of the experiment or the response phase of the experiment. Students were not permitted to participate in both phases. A total of 51 couples (102 individuals) participated in this phase of the project. There were 57 female participants, 44 male participants, and 1 participant who chose not to specify their sex. The mean age of the participants was 19.63 years old (SD =2.16) and participants were primarily white (n=59). Other races/ethnicities included black (n=28), Asian (n=3), and Hispanic (n=8). The class rank breakdown was as follows: Freshman (n=44), Sophomore (n=29), Junior (n=16), Senior (n=6), and Graduate/Other (n=5).

Procedures. To prepare for the experiment, two thermoregulatory masks and two apocrine masks were placed in air-tight containers and brought to room temperature. The two air-tight containers holding the masks were placed on a table inside the lab the experiment was taking place in. Each container held two surgical masks and each container was marked with either a purple dot (for the apocrine sweat condition) or a gold dot (for the thermoregulatory sweat condition).

After arriving in the lab, participants were asked to complete pretest measures which included demographic questions as well as the Relational Satisfaction Scale (Hendrick, 1988) and the Emotional Contagion Scale (Doherty, 1997). For the complete scales, see Appendix B. A further discussion of each of these scales can be found in the Instrumentation section below. After completing these pretest measures, each participant was asked to choose two topics they felt they had argued about frequently over the course of their relationship. They were asked to rank each topic in intensity from 1-10, with 1 being least intense and 10 being most intense. The researcher examined each of the 4 topics chosen (two from each participant) and selected one of them according to the following procedures. If the participants listed identical topics (so that

there were only two total topics to choose from), the topic with the lowest average intensity was selected. If the participants listed one identical topic and one different topic (so that there were three total topics to choose from), the matching topic was selected. If the participants listed completely different topics (so that there were four total topics to choose from), the topic with the lowest intensity was selected. Before selecting a topic, each participant was asked if they were willing to discuss the topic with their partner. If the participant indicated they were not willing to discuss this topic, another topic was selected. Once a topic was selected, the participants were asked to answer several questions about how discussions about the topic *typically* went using an adapted version of the Revised Conflict Tactics Scale (CTS). This scale was modified to exclude any items that pertained to physical or verbal abuse (as per IRB requests). These questions were primarily meant to capture anger tactics and conciliatory tactics from both the self and the partner.

After these measures were completed, instructions for the next part of the study were read. The instructions were read prior to random assignment in order to avoid problems with subconscious experimenter expectancy effects. After instructions were given, the experimenter left the room to observe, and the participants flipped a coin. The results of this coin toss determined which condition the participants would be in (apocrine sweat or thermoregulatory sweat). There were 54 participants in the apocrine sweat condition (27 dyads, 53%) and 48 participants in the thermoregulatory sweat condition (24 dyads, 47%). After the coin toss, the participants opened the corresponding air-tight container and removed the surgical masks. They placed the masks over their noses (in order to preserve as much normalcy as possible, masks were modified so that only the nose was covered, leaving the mouth and jaw free to function normally) and made themselves comfortable on the couch. After one minute, they were allowed

to begin talking about the previously selected topic. This conversation lasted for five minutes. Afterwards, the experimenter came back into the room and the participants were asked to complete the post-test measures. These measures were similar to the modified version of the CTS completed prior to the conversation, but instead of asking about the typical discussion about the topic, these items asked participants to rate how this discussion compared to their typical discussion about the topic. Once these measures were completed, participants were free to leave.

Instrumentation. Several measures were used during the course of this study. These instruments included the Emotional Contagion Scale (Doherty, 1997), the Relationship Assessment Survey (Hendrick, 1988), and a heavily modified version of the Revised Conflict Tactics Scale (Straus et al., 1996). Each of these instruments will be briefly discussed below. The complete scales can be found in Appendix B.

The Emotional Contagion Scale is a 15-item unidimensional measure which assesses a respondent's susceptibility to catching the emotions of others. The survey measures susceptibility to emotional contagion by assessing participant's responses to encountering someone displaying one of the basic, cross-culturally universal emotions (happiness, sadness, fear, anger, and love) (Ekman, 1992, Doherty, 1997). The measure uses a 5-point scale, where 1=never, 2=rarely, 3=sometimes, 4=usually, and 5=always. Past studies have examined emotional contagion in light of several measures to which it should be logically related. Emotional contagion has been shown to be positively related to reactivity to social situations, emotionality, sensitivity to others, and empathy (Doherty, 1997; Lundqvist, 2006; Lundqvist & Kevrekidis, 2007), while it is negatively related to emotional stability and alienation from others (Doherty, 1997). While some (Bhullar & Bains, 2013) argue that the Emotional Contagion Scale should be treated as a multidimensional model, Doherty (1997) argues that, while items may load

onto two factors (positive and negative emotions), a unidimensional model is most appropriate for the sake of parsimony. For Study 2, the Emotional Contagion Scale had an alpha-reliability of 0.78, a mean of 3.51 and a standard deviation of 0.51.

The Relationship Assessment Survey (Hendrick, 1988) is a 7-item unidimensional scale assessing how satisfied an individual is with their relationship. Answers are reported on a 1-5 scale with 1 being "Low" and 5 being "High." This instrument has been correlated with several logically consistent measures, such as love, sexual attitudes, self-disclosure, commitment, investment in a relationship, marital satisfaction, and personal constructs (Hendrick, 1988; Hall, Hendrick, & Hendrick, 1991; Hendrick & Hendrick, 1995; Hendrick, Dicke, & Hendrick, 1998). It has also been shown to have consistent measurement properties across ethnically and age-diverse couples (Hendrick, Dicke, & Hendrick, 1998). This instrument had an alpha-reliability of 0.75, a mean of 4.45, and a standard deviation of 0.47.

The final instrument was a 20-item scale assessing the amount of anger and conciliation tactics displayed during a conflict. This instrument was based on the Revised Conflict Tactics Scale (Straus et al., 1996), an instrument containing 39 items intended to capture various conflict tactics used during relational conflict, including negotiation, verbal aggression, and physical aggression. Concerns from IRB about the obligation to report potential abuse required that I omit any items pertaining to physical abuse or severe verbal aggression (e.g., threatening the partner with violence). Therefore, the scale was revised to omit these items, and then expanded to include more items involving varying degrees of anger and conciliation tactics. As such, this scale strayed too much from the original instrument to use without performing follow-up analyses to ensure it was an accurate assessment of the variables of interest. Therefore, a Principal Components Analysis (PCA) with varimax rotation and an extraction criterion of an

eigenvalue>1 was performed on the new instrument. This analysis revealed some problems. The initial analysis loaded onto three factors with an eigenvalue >1, but individual factor loadings for two of these factors were quite poor (all <0.4). Further inspection of the poorly fitted items revealed that the items relating to conciliation/negotiation tactics were not well-suited to the data. Deleting these items created a much better instrument, but caused the instrument to focus only on anger tactics, rather than both anger and conciliation. Although this is a slight problem for this study, the hypotheses specifically dealt with anger, meaning the missing data should not have much influence on the conclusions. After removing the conciliation items from the instrument, items loaded onto two factors (Eigenvalues=5.07 and 2.10), with factor loadings ranging from 0.51 to 0.85. The two factors represented by the scale were experiences of self-anger (with items such as "I get angry when discussing this topic") and perceptions of their partner's anger ("My partner seems to yell a lot when discussing this topic"). The analyses presented below will examine levels of anger using the two subscales of anger found above (self-anger and other-anger). The instrument was delivered to participants twice. The first time, participants answered the questions while thinking about how the *typical* discussion about this topic went. In this instance, the self-anger scale yielded an alpha-reliability of 0.84, a mean of 2.95, and a standard deviation of 0.89. The other-anger scale yielded an alpha-reliability of 0.82, a mean of 2.76, and a standard deviation of 0.93. The second time participants completed this measure, they were asked to think about how the preceding discussion differed from their typical discussion of this topic. In this case, the self-anger scale resulted in an alpha-reliability of 0.72, a mean of 1.65, and a standard deviation of 0.59. The other-anger scale resulted in an alpha-reliability of 0.70, a mean of 1.58, and a standard deviation of 0.46. I will now turn my attention to outlining the results of this study.

Results

The analyses for Study 2 used two measures of anger/aggression, one 6-item scale (α=0.79) gauging how much the self displayed anger when compared to the ordinary conflict discussion and one 5-item scale (α=0.75) gauging how much the partner displayed anger when compared to the ordinary conflict discussion. Each hypothesis was tested using both measures of anger: self-anger and other-anger. Independent variables included type of sweat (thermoregulatory vs. apocrine), biological sex, susceptibility to emotional contagion (α=0.78), relational satisfaction (α=0.76), and conflict intensity (a single, 10-point item which asked participants to rate how intense discussions of this topic *usually* are).

In order to account for potential dyadic interdependence, regression analyses were performed using clustered robust standard errors. Interdependence between dyads violates the assumptions of OLS regression, thus leading to biased standard errors. Using clustered robust standard errors rather than ordinary standard errors corrects for the bias in the error terms, thus ensuring a greater degree of accuracy in hypothesis testing (Cameron & Miller, 2015). Clustered robust standard errors have been used to account for interdependence of data in a variety of contexts. For example, when analyzing finance data, researchers often sample multiple data points from the same group of firms. In these cases, the residuals may be correlated according to firm or according to time, which would bias the OLS standard errors (making hypothesis testing difficult or impossible to perform). In order to account for this inherent interdependence, clustered robust standard errors are often employed (Thompson, 2011; Petersen, 2008; Cohen, Polk, & Vuolteenaho, 2003). In fact, Petersen (2008) demonstrated that using clustered robust standard errors when data is correlated in this way reliably produces unbiased standard errors, while the other methods tested were less reliable. Another example can be found in research

concerning state and local politics. In this area, data from individual respondents is often clustered at the state or district level, meaning that individual responses from similar areas may be interdependent. In order to correct for this problem, some researchers turn to clustered robust standard errors (Branton, 2004; Buckley & Westerland, 2004; Primo, Jacobsmeier, & Milyo, 2007). Primo, Jacobsmeier, and Milyo (2007) demonstrated that calculating clustered standard errors can be both more straightforward and more practical than multi-level modeling techniques. While the preceding research used data clustered according to firm or state, the present study uses data clustered according to dyad. Because each member of the dyad may be influencing the responses and reactions of the other member, the data may not be fully independent (a requirement for obtaining unbiased estimates), thus clustered robust standard errors were needed to correct for this problem. As pointed out by multiple scholars (Kezdi, 2004; Bertrand, Duflo, & Mullainathan, 2004; Hansen, 2007; Primo, Jacobsmeier, & Milyo, 2007; Thompson, 2011) clustered standard errors require a sufficient number of clusters in order to work effectively. The minimum number of clusters necessary is 25. The present study utilized 51 dyads, meaning that the number of available clusters was more than sufficient. It should be noted that using clustered robust standard errors not only corrects for interdependence between dyads, it also corrects for any other instances of heteroskedasticity in the data; therefore, tests for heteroskedasticity were not performed for this analysis. A table of the intraclass correlations between dyads on the variables of interest is presented in Table 4.1. As is evidenced by this table, there is some degree of interdependence on some of the variables of interest (which would lead to problems with a traditional analysis), but using clustered robust standard errors helps correct for this problem.

Table 4.1. Intraclass Correlations by Dyad

	Intraclass Correlation	SE	F	P	R^2
Emotional Contagion	0.01	0.14	0.92	0.61	0.47
Relational Satisfaction	0.54	0.09	3.37	0.000	0.77
Conflict Intensity	0.42	0.11	2.42	0.001	0.70
Self Anger	0.38	0.12	2.23	0.002	0.68
Other Anger	0.24	0.13	1.63	0.06	0.61

This study's hypotheses concern the independent and interactive effects of type of sweat, gender, susceptibility to emotional contagion, relational satisfaction, and conflict intensity on self-anger and other-anger during a conflict discussion. Hierarchical regression analyses were employed to test these hypotheses. A two-step regression equation was estimated for measures of self-anger and other-anger. The main effects of type of sweat, gender, emotional contagion, relational satisfaction, and conflict intensity were entered in the first step, and the products of both sweat and gender and sweat and emotional contagion (representing the two-way interactions between these variables) were entered in the second step. Organizing the analyses in this way allows one to account for previous effects, thus demonstrating the true contribution of the interaction variables. Therefore, two models were estimated (one for each measure of anger) using type of sweat, gender, emotional contagion, relational satisfaction, and conflict intensity as the first block variables and the interactions between type of sweat and gender (sweat*gender) and type of sweat and susceptibility to emotional contagion (sweat*emotional contagion) as the second block variables. Variables were centered at the mean.

The first model used ratings of self-anger as the dependent variable. To start, I performed a simple difference of means test comparing mean scores of self-anger for those exposed to thermoregulatory sweat versus those exposed to apocrine sweat. The means for the two groups were significantly different ($t=2.46$, $p=0.007$). Those exposed to thermoregulatory sweat scored

an average of 1.81 (SD=0.58) on the self-anger measure, while those exposed to apocrine sweat scored an average of 1.53 (SD=0.56) on the self-anger measure, a difference of −0.28 units.

Because there are many variables which might influence displays of self-anger that were not captured in the initial analysis, a two-step multivariate regression was performed in order to control for the effects of these additional variables. The variables included in the first block accounted for approximately 16% of the total variance in ratings of self-anger ($F_{5, 50}$=5.78, $p<0.001$). The effects for type of sweat, susceptibility to emotional contagion, and relational satisfaction were all significant at the 0.05 level. The negative coefficient for type of sweat indicates that exposure to apocrine sweat significantly decreased self-anger when compared to exposure to thermoregulatory sweat ($b=-0.27$, $\beta=-0.24$ $p<0.01$). Thus, Hypothesis 1 was supported by this model. Similarly, the negative coefficient for emotional contagion ($b=-0.16$, $\beta=-0.15$, $p<0.05$) indicates that an increase in susceptibility to emotional contagion is associated with a decrease in self-anger. Finally, the negative coefficient for relational satisfaction ($b=-0.29$, $\beta=-0.21$, $p<0.05$) indicates that as relational satisfaction increases, self-anger decreases. The coefficient for gender was not significant ($b=-0.13$, $\beta=-0.12$, $p>0.05$), indicating that males and females did not differ significantly on their ratings of their own anger. Thus, Hypothesis 2 was not supported by this data.

The additional variables included in the second block left the R^2 value at 0.16 ($F_{7, 50}$=4.11, $p<0.01$), meaning the combination of variables accounted for approximately 16% of the variance in self-anger. The change in R^2 from Block 1 to Block 2 was 0.001, or 0.1% of the total variance accounted for by the model. Post hoc tests reveal that this change was not statistically significant ($F_{2, 50}$=0.13, $p>0.05$), which indicates that the interaction variables were not

significant contributors to our overall understanding of self-anger. Therefore, Hypotheses 3 & 4 were not supported by this model. Results of this analysis are found in Table 4.2.

Table 4.2. Two-Step OLS Regression Estimates for Ratings of Self-Anger.

Dependent Variable	Block 1--Main			Block 2—Interactions		
	Variable	b	β	Variable	b	β
Self Anger	Sweat	−0.27***	−0.24	Sweat x Sex	0.05	0.04
	Gender	−0.13*	−0.12	Sweat x Contagion	0.05	0.03
	Emotional Contagion	−0.16**	−0.15			
	Satisfaction	−0.26**	−0.21			
	Intensity	0.02	0.06			
	R^2	0.16		R^2	0.16	
	F	5.78***		F	4.11***	
				R^2 change=0.16	0.002	
				F Change=0.002	0.13	

*p<0.05, **p<0.01, ***p<0.001

The second model used ratings of other-anger as the dependent variable. This analysis began with a difference of means test, which revealed that the means of the two groups (apocrine sweat v. thermoregulatory sweat) were significantly different (t=3.07, p=0.001). The mean score of other-anger for those exposed to thermoregulatory sweat was 1.75 (SD=0.48), while the mean score of other-anger for those exposed to apocrine sweat was 1.47 (SD=0.42), a difference of −0.28 units.

In order to control for the influence of potentially confounding variables, a two-step OLS regression model was estimated. The variables included in the first block accounted for approximately 18% of the total variance in ratings of self-anger ($F_{5, 50}$=4.95, p<0.01). The effects for type of sweat and relational satisfaction were significant at the 0.05 level. The negative coefficient for type of sweat indicates that exposure to apocrine sweat significantly decreased other-anger when compared to exposure to thermoregulatory sweat (b=−0.27, β=−0.28, p<0.01).

Thus, Hypothesis 1 was supported by this model. Similarly, the negative coefficient for relational satisfaction ($b=-0.26$, $\beta=-0.26$, $p<0.05$) indicates that as relational satisfaction increases, perceptions of other-anger decreases. The coefficient for gender was not significant ($b=-0.09$, $\beta=-0.10$, $p>0.05$), indicating that males and females did not differ significantly on their ratings of their partner's anger. Similarly, the coefficient for emotional contagion ($b=-0.10$, $\beta=-0.11$, $p>0.05$) was not significant, indicating that susceptibility to emotional contagion was not significantly associated with perceptions of other-anger.

The additional variables included in the second block yielded an R^2 of 0.18 ($F_{7, 50}=3.49$, $p<0.01$), meaning the combination of variables accounted for approximately 18% of the variance. The change in R^2 from Block 1 to Block 2 was 0.003, or 0.3% of the total variance accounted for by the model; this change was not significant ($F_{2, 50}=0.26$, $p>0.05$), indicating the interaction variables were not significant contributors to our understanding of other-anger. Thus, Hypotheses 3 & 4 were not supported. The results of this analysis can be found in Table 4.3.

Table 4.3. Two-Step OLS Regression Estimates for Ratings of Other-Anger.

Dependent Variable	Block 1--Main			Block 2—Interactions		
	Variable	b	β	Variable	b	β
Other Anger	Sweat	−0.27***	−0.28	Sweat x Sex	−0.06	0.06
	Gender	−0.09*	−0.10	Sweat x Contagion	0.10	0.08
	Emotional Contagion	−0.10**	−0.11			
	Relational Satisfaction	−0.26**	−0.26			
	Conflict Intensity	0.001	0.003			
	R^2	0.18		R^2	0.18	
	F	4.95***		F	3.49***	
				R^2 change=0.16	0.003	
				F Change=0.002	0.26	

*p<0.05, **p<0.01, ***p<0.001

After reviewing the results of these two analyses, one can conclude that there is full support for Hypothesis 1 (anger responses decrease in response to apocrine sweat exposure), but there is no support for Hypotheses 2-4 (women will report less anger than men, responses to apocrine sweat will be stronger for women than for men, and responses to apocrine sweat will be stronger for higher levels of emotional contagion). The results of these four hypotheses are discussed in further detail below.

Discussion

The results outlined above contain interesting revelations about the effects of stress-induced apocrine sweat on human interactions. This study examined the effects of apocrine sweat on the amount of anger experienced or perceived during a conflict discussion. The effects of biological sex and susceptibility to emotional contagion on anger were also examined, with a particular interest in the interaction between apocrine sweat and these two variables. In this section, the results outlined above will be discussed in further detail.

Apocrine Sweat and Anger

As hypothesized, exposure to stress-related apocrine sweat was significantly associated with decreases in anger during a conflict discussion for both measures of anger represented in this study. Exposure to apocrine sweat was associated with a 0.27 unit decrease in both self- and other-anger. Thus, exposure to apocrine sweat during a conflict discussion led to lower levels of reported anger during that discussion when compared to thermoregulatory sweat. I will discuss two possible explanations for these findings, which I will refer to as the Convergent Explanation and the Divergent Explanation.

The Convergent Explanation implies that exposure to apocrine sweat induced a convergent state of fear in the participants. Thus, the participants perceived that *someone* in the

room was afraid (and therefore producing apocrine sweat) and they became afraid as well. This fear then caused the participants to be less angry (a typical response to fear is to exhibit avoidant, rather than angry behaviors (Lundqvist & Dimberg, 1995) in order to preserve themselves in the face of the only potential threat in the room—their partner. This explanation basically says that in the face of fear, most people will become less angry and more avoidant of the conflict than they would under more normal circumstances. Thus, when exposed to the purported chemical emotional contagion of apocrine sweat, participants were more afraid of their partners than their thermoregulatory counterparts, and it was this experience of fear which led to the corresponding decrease in anger.

The Divergent Explanation, on the other hand, says that it is not *self*-preservation that causes the decrease in anger, but *other*-preservation that is the real cause. In this explanation, exposure to apocrine sweat does not cause feelings of fear in the participant, but instead causes feelings of concern for their partner (a notion supported by Van der Schalk, et al. [2011], who found that facial displays of fear lead to divergent feelings of either aversion or concern). Sensing fear in the room (and having no reasons to suspect they themselves are afraid) leads individuals to subconsciously assume that their partner is experiencing fear. In the absence of other obvious sources of that fear, individuals may subconsciously assume that their partner is afraid of *them*. In an effort to allay their partner's fear of them, individuals may become less angry in order to demonstrate to their partner that they have nothing to fear. Future research is required to determine which explanation is more accurate.

Interaction with Biological Sex. The hypothesis that sex would have an effect on the amount of anger displayed or perceived during a conflict discussion was not supported at the 0.05 level after controlling for the effects of the additional variables. Without controlling for

these effects, self-anger was significantly lower for women than for men (thus, women reported themselves to be less angry than their male counterparts), but there were no significant differences for other-anger. If other-anger *had* reached significance (and it was awfully close at p=0.06), it would have meant that men perceived their partners as being angrier than women perceived their partners to be. Regardless, however, none of these relationships remained significant after controlling for the other variables. A lack of significant differences in anger during a conflict discussion might be a result of the discussion itself. While women are expected to stifle anger displays in their daily lives, perhaps they feel less restricted when it comes to displaying their anger to an intimate partner. Similarly, perhaps while men are allowed to display their anger in their daily lives without fear of negative social consequences, perhaps they are more likely to exercise control of that emotion when they are discussing a conflict with an intimate partner. A final explanation is that there simply were not enough data points available to capture a discernable difference between the two sexes. Because the results were in the hypothesized direction and approached significance in each of the three models, and because the dataset was relatively small (51 dyads and 102 total participants), this is certainly a possibility.

Further, the expected interaction between biological sex and apocrine sweat (which received strong support in Study 1), was not supported in Study 2. While apocrine sweat did have a significant effect on anger in both models, this effect was not any stronger for women than it was for men. There are several explanations for this lack of support, but future research is the only way to ascertain which is most accurate. First, as previously stated, perhaps there are differences in expectations for how men and women argue or in how intimate partners argue that serve to alter the effects of apocrine sweat when dealing with a conflict. For the sake of argument, let's assume that the sex differences detailed above (women reported less anger than

men) were actually statistically significant. If that was the case, perhaps the exposure to apocrine sweat made women *more* angry and men *less* angry, thereby resulting in no discernible differences between men and women on anger after exposure to apocrine sweat. Second, if the Convergent Explanation (outlined above) is more accurate, perhaps the experience of fear leads to different behavioral outcomes in men and women, and the effect of those behavioral outcomes manifests itself as different conflict strategies. On the other hand, if the Divergent Explanation is more accurate, perhaps sensing the fear of one's partner creates different responses in men and women, leading to the same overall outcome (different conflict strategies) that was previously discussed. If either of these two explanations are accurate, it would mean that this particular study cannot assess if the effects of apocrine sweat are stronger for women than for men, because the effects may be altogether *different* for women and men. This is not an issue I would have had in Study 1, because Study 1 did not deal with any real-time interactions between participants. Future studies could better capture the effects of apocrine sweat for men and women by examining additional emotional responses (instead of just anger).

Interaction with Emotional Contagion. As was the case in Study 1, the expected interaction between susceptibility to emotional contagion and apocrine sweat was not observed in Study 2. Apocrine sweat did not have different effects for different levels of emotional contagion. To briefly recap the previously posited explanation, perhaps the fact that the olfactory system bypasses the thalamus (a key element in stimulus-processing) means that chemical emotional contagion in the form of apocrine sweat is not subjected to the same levels of processing as visual or auditory sources of emotional contagion. If this is the case, it can be argued that apocrine sweat and other forms of chemical emotional contagion are an even more primitive form of the "primitive empathy" than is emotional contagion.

In sum, the results of this study show that stress-induced apocrine sweat *does* have an effect on the amount of anger experienced during a conflict discussion; however, this effect is not any different for different levels of biological sex or emotional contagion. Thus, apocrine sweat may lower levels of anger during a conflict discussion, regardless of one's sex or susceptibility to emotional contagion. The next chapter will focus on overall implications of this project, as well as limitations and directions for future research.

CHAPTER FIVE

IMPLICATIONS, LIMITATIONS, AND CONCLUSION

The final chapter of this project begins by highlighting implications of the studies reported here. I will then move on to discuss limitations and make suggestions for future research. Finally, there will be a brief word of conclusion.

Implications

The results of these two studies indicate that apocrine sweat has discernible effects on human perceptions and human interactions. These findings offer strong support that apocrine sweat is a form of chemically induced emotional contagion. This project included a total of nine hypotheses (five in Study 1 and four in Study 2). A description of each hypothesis and whether it was supported or not can be found in Table 5.1. The hypotheses for Study 1 predicted that exposure to apocrine sweat, increased susceptibility to emotional contagion, and being female would each contribute to increases in the experience of fear in response to a frightening stimulus. Each of these three hypotheses was supported. Another hypothesis for Study 1 predicted that the effects of apocrine sweat on fear would be stronger for women than for men. This hypothesis also received support. The final hypothesis for Study 1 predicted that the effects of apocrine sweat on fear would increase as susceptibility to emotional contagion increased. This hypothesis was not supported. The first hypothesis for Study 2 predicted that exposure to apocrine sweat during a conflict discussion would be negatively correlated with levels of anger during that conflict. This hypothesis was supported. Other hypotheses for Study 2 predicted that women would display lower levels of anger during a conflict and that the effects of apocrine sweat on anger would be stronger for women than for men. These hypotheses were not fully supported by the data. Finally, Study 2 predicted that the effects of apocrine sweat on anger would be stronger

as susceptibility to emotional contagion increased. As with Study 1, this hypothesis was not supported. The lack of an interaction between susceptibility to emotional contagion and apocrine sweat may imply chemical emotional contagion follows a different—possibly more primitive—path than other forms of emotional contagion. Because emotional contagion is processed (at least in part) by the thalamus, and because the olfactory system bypasses the thalamus altogether, chemical emotional contagion may be its own unique form of emotional contagion. In short, exposure to apocrine sweat—what Hatfield, Cacioppo, and Rapson (1994, p. 5) would call a "precipitating stimul[us]"— produced corresponding or complementary emotions in other individuals—the very definition of emotional contagion.

Table 5.1. Overview of Project Hypotheses

Number	Hypothesis	Support?
1.1	Exposure to apocrine sweat will be positively associated with increased levels of fear	Supported
1.2	Susceptibility to emotional contagion will be positively associated with increased levels of fear	Supported
1.3	Women will be more susceptible to emotional contagion than men	Supported
1.4	Women will have stronger reactions to apocrine sweat than men	Supported
1.5	Those who are more susceptible to emotional contagion will have stronger reactions to apocrine sweat than those who are less susceptible to emotional contagion	Not Supported
2.1	Exposure to apocrine sweat during a conflict discussion will be associated with lower levels of anger during that conflict	Supported
2.2	Women will display lower levels of anger during a conflict discussion	Partially Supported
2.3	The effects of apocrine sweat on anger during a conflict discussion will be stronger for women than for men	Not supported
2.4	The effects of apocrine sweat on anger during a conflict discussion will be stronger for those who are more susceptible to emotional contagion than those who are less susceptible to emotional contagion	Not Supported

This project advances our understanding of the effects of stress-induced apocrine sweat in two important ways. First, Study One utilized a different type of stimulus than preceding studies. While previous work focused on rating ambiguous or neutral stimuli (particularly still images of

ambiguous faces), this study examined the effects of apocrine sweat on a moving image of an already emotionally charged situation. Using a video as the stimulus contributes to increased validity of the experiment. This increase in validity is due to increased realism in the stimulus. To further explain, imagine visual stimuli arranged along a continuum, with unrealistic images on one end and very realistic images on the other. At the leftmost point (aka, most unrealistic) would be drawings, towards the middle-left would be still images, towards the middle-right would be moving images, and at the rightmost point (aka most realistic) would be virtual reality (or actual reality, depending on how one chooses to define "visual stimuli"). Previous research has used still images, which can be seen as moderately realistic. This study used moving images, which can be seen as a more realistic stimulus than has been previously used. Future studies may incorporate increasingly realistic stimuli to better understand the contributions of apocrine sweat on human perceptions and behavior. Further, this study used an already emotionally valenced stimulus (a frightening stimulus), while prior research has used only neutral or ambiguous stimuli. This change expands our understanding of the influences of apocrine sweat on human perceptions. While it has been previously noted that apocrine sweat increases the likelihood that one will rate an ambiguous face as being more fearful, this study shows that even when fear is already clearly present, apocrine sweat has an effect on one's perceptions, serving to ramp up the fear that was already there.

Another major contribution is found in Study Two. This study is the first to explore the effects of stress-induced apocrine sweat on actual human interactions. Previous research (up to and including Study One of this project) has exclusively examined the effects of apocrine sweat when exposed to only one person who does not interact with anyone else. This study examined the effects of apocrine sweat on two people interacting with each other about a topic of

disagreement. This study helps us to better understand how apocrine sweat affects others in (so-to-speak) real-time. Since emotional contagion is something that usually occurs *during* interactions with others, it is important to understand how chemical emotional contagion affects people during actual interactions. This study takes the first step in doing just that.

Limitations

There were several limitations to these studies. These limitations primarily include concerns about the donor sweat and concerns about the instrumentation. Each limitation will be discussed below.

Sweat. Deodorant is a steady part of our cultural hygiene. At the onset of puberty (when apocrine glands begin to produce sweat), many children in the United States are given a "talk" about the importance of deodorant and when, how, and why it should be applied. From that point on, deodorant becomes an important part of most peoples' daily ritual. The ingredients in antiperspirant and deodorant are intended to stifle both sweat production and bacterial activity around the apocrine glands. This changes both the amount of sweat secreted, and the scent of the sweat on the skin. The preceding studies (and other studies like them) use sweat collected from individuals who are not wearing deodorant or antiperspirant. This is a major limitation of the study design. While it is useful to understand the effects of apocrine sweat on human interactions in our most "natural" state, it is arguably more useful to understand the effects of apocrine sweat on human interactions in our most *typical* state, i.e., wearing deodorant. Future studies should work to assess whether apocrine sweat combined with deodorant changes the way people respond to apocrine sweat in general. If deodorant *does* alter the way we respond to apocrine sweat, future studies should seek to determine in what ways the effects are altered. Further,

future studies should account for cultural differences in deodorant use, as these differences may have an effect on the conclusions drawn from any such studies.

Another limitation concerning the sweat is that sweat samples were not the same for every participant. In order to maintain the integrity of the sample, the cotton pads were discarded after 1 week of use (in accordance with similar studies concerning apocrine sweat). This change represents a potential threat to internal validity, because it essentially means that the instrument changed over the course of the study. Because everyone has a unique olfactory signature and thus unique pheromonal secretions, some may argue that changing from whom the apocrine sweat came may have influenced results. However, I view this diversity as a strength rather than a weakness. These studies support the idea that it does not matter from whom the pheromones came, that the reactions are not the result of one or two particularly compelling donors, but are instead the result regardless of who is secreting the chemicals. However, the potential for one or two particularly compelling donors *does* exist. While these studies suggest that most people are capable of influencing others via their apocrine sweat, there is still the possibility that some people have a *larger* amount of influence than others. These two studies did not address this possibility. Further, because participants had access to the study description before signing up to donate their sweat, it is possible a self-selection bias was in play, where those who felt they had particularly strong sweat either avoided signing up (out of fear of embarrassment from not being able to wear deodorant) or signed up more often (because they felt they were a "good candidate" for the study). Future research should seek to determine if certain people's apocrine sweat is more influential than that of other's, and (if so) in what ways.

A further limitation involving sweat concerns the general demographics of the donors and the receivers. Due to the recruitment strategy employed (college students enrolled in

Communication Studies courses), most of the donors were young, white people and most of the recipients were of a similar demographic. Thus, the donor-recipient relationship was primarily that of an "in-group," as far as race and ethnicity were concerned. I did not separate donated sweat by race/ethnicity, therefore, I could not determine if the effects of inter-racial exposure were any different than the effects of intra-racial exposure. Further, I did not separate donated sweat by biological sex, thereby preventing me from assessing if there are different effects for either intra-sex or inter-sex pairings. As demonstrated by Van der Schalk et al. (2011), emotional contagion for out-group members usually results in divergent emotions, while emotional contagion for in-group members more frequently results in convergent emotions. Thus, future studies might seek to determine if the effects of apocrine sweat are different for different racial or sex configurations, and if so, in what ways.

The final limitation involving sweat that I will discuss here involves the application of the sweat to the receivers. The sweat was placed in direct contact with the participants' noses, rather than allowed to more naturally permeate the room. As most people do not take a large whiff of a stranger's armpit before watching a scary movie, nor before beginning an argument with their significant other, the application of the sweat presents a threat to the external validity of these experiments. As with the choice to collect sweat untainted by deodorant, the choice to apply the sweat directly to the participants' noses was intended to capture the maximum effects of apocrine sweat in these specific situations. There is a strong possibility that the effects of apocrine sweat documented in these two studies would be lessened if the sweat was positioned further from the individuals participating. However, as demonstrated by Bensafi et al. (2003), conscious detection of an odor is not necessary for that odor to influence those exposed to it. Instead, some odors affect individuals attitudes and behaviors even when they are unaware there is any odor in the

room at all. As such, it is also possible that the effects of apocrine sweat would hold steady even if the application was not so (literally) in the face of the participants. Future research is necessary to determine if the effects of apocrine sweat remain unchanged under different exposure conditions.

Instrumentation. The first instrumentation limitation I will discuss concerns the instruments in general. The measures employed in these studies primarily assessed *perceptions,* not actual behavior. Because these instruments were self-report measures, perceptions about the individual's own experiences and perceptions about the behavior of their partner were the only things they could capture. Whether *actual behavior* changes in response to apocrine sweat, or merely *individual perceptions* about that behavior change remains to be seen. Incorporating physiological data and coding for certain behaviors via trained coders for future studies would help to answer this question.

A second instrumentation limitation can be found in the instrument assessing conflict tactics employed in Study 2. The original intent of the instrument was to assess the prevalence of both anger and conciliation tactics during both the typical conflict discussion and the current conflict discussion. As detailed in Chapter 4, this instrument did not hold together very well in this study. While the anger items did their job respectably, the conciliation items did not, thus limiting the amount of information provided by this study. Further, the phrasings of the post-test questions are potentially problematic. These items were phrased to assess if the amount of anger *differed from the typical discussion*, rather than just assessing the amount of anger on its own. This phrasing choice may have limited the predictive power of the study. Instead, it may have been better to assess the typical levels of anger and then assess the actual level of anger displayed during the conflict. Analyses would then control for the typical level of anger and

allow for more direct comparisons between the two levels. Future studies should address this limitation.

With sufficient future research, these findings may suggest interesting new avenues of exploration in the ways we communicate with one another. One such application relates to commercial uses of apocrine sweat. Given the results of these studies, there might be an interesting niche market for synthesizing and deploying apocrine sweat. For example, the film industry may try experimenting with, for lack of a better phrase, "smell-o-vision." For example, if the smell of apocrine sweat increases a viewer's experiences of fear while watching a scary movie, it makes perfect sense that this industry will want to use this knowledge for financial gain. Administering apocrine sweat prior to particularly frightening moments would increase the amount of fear experienced by movie-goers. And as one of the driving forces for ticket sales to horror movies is how scary the movie is, any increases in the fear of audiences would translate to increased ticket sales. Further, perhaps particularly volatile couples would benefit from the reduced anger derived from exposure to apocrine sweat. However, before this suggestion becomes too exciting, major explorations on the effects of apocrine sweat on couples should be done. For instance, there is a possibility that those who are prone to abuse do not react to apocrine sweat in the same ways as those who are not prone to abuse. As has been shown by Jacobson and Gottman (1998), abusers (particularly sociopathic abusers) do not have the same physiological responses to conflict as others (particular differences include heart rate and galvanic skin responses). Perhaps these same people would not respond to apocrine sweat in the same ways as others. Instead of becoming less angry when exposed to the fear-sweat of others, perhaps abusers will become *more* angry, thereby making exposure to apocrine sweat extremely counterproductive in helping these relationships. Again, future research which examines the

effects of apocrine sweat on abusers versus non-abusers is needed to determine the efficacy of such a course of action.

In addition to designing tools to artificially increase exposure to apocrine sweat, there may be some advantages to designing tools to *eliminate* the effects of apocrine sweat. If exposure to the apocrine sweat of others increases experiences of fear, there are numerous industries which might benefit from tools which eliminate this effect. For example, the airline industry may attempt to make flying more comfortable for many people by eliminating the smell of fear left by others (though knowing the airline industry, there would undoubtedly be a hefty surcharge for this service). Schools concerned with test anxiety (and concerned that test anxiety might spread to other students, thus limiting their performances) may seek to deploy apocrine sweat-canceling tools to protect their students from catching the stress of more anxious test-takers. There are numerous settings which might benefit from mitigating the effects of anxiety left behind by others.

Conclusion

If communication is allowed to include unintentional behaviors that nonetheless convey a message to a receiver, human semiochemicals are certainly a form of nonverbal communication. Sweat secreted in response to stress creates an odor that humans subconsciously recognize and respond to in discernible ways. In other words, humans are susceptible to influence from the chemical communications of others. This project attempted to understand at least some of the ways human apocrine sweat influences individuals' perceptions while watching a scary video and while arguing with their romantic partner. After reviewing literature concerning the sense of smell, the creation of human body odor, and the impact of this odor on humans, I conducted two experiments assessing the effects of apocrine sweat as compared to thermoregulatory sweat. The

first study examined how exposure to apocrine sweat while viewing a scary video influences how that video is perceived. Results of this study indicate that apocrine sweat increases the experiences of psychological and physical fear, and leads individuals to expect others would be more frightened of the stimulus. Results also indicate that apocrine sweat has a stronger effect on the fear responses of women than it does on men. Further, while increased susceptibility to emotional contagion was associated with increases in fear, susceptibility to emotional contagion did not influence the effects of apocrine sweat—instead the effects held steady regardless of how susceptible one was to emotional contagion. The second study examined how exposure to apocrine sweat during a conflict discussion with a romantic partner influenced the amount of anger experienced during that discussion. Results of this study indicate that apocrine sweat decreases the amount of anger experienced (on the part of the self) and perceived (on the part of the other). The effects of apocrine sweat on anger during a conflict discussion were not different for women than they were for men, and they did not differ according to susceptibility to emotional contagion.

The research conducted in this project supports the idea that stress-induced human apocrine sweat influences the perceptions and interactions of others in unique and identifiable ways. This sweat is associated with increases in fear during a fear condition and decreases in anger during a conflict condition. This project contributes to our understanding of the nuances and hidden complexities of human interactions. So the next time you hear an evil villain tauntingly shout out "I can smell your fear," know that…they just might be right. But the effects of that fear may not be quite what the villain imagined.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD DOCUMENTATION

Donation: IRB Approval

ACTION ON PROTOCOL APPROVAL REQUEST

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu | lsu.edu/irb

TO: Renee Edwards
Communication Studies

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: November 17, 2014

RE: **IRB#** 3555

TITLE: Chemical Communication: The Effects of fear pheromones on human perceptions and interactions (Study 1)

New Protocol/Modification/Continuation: New Protocol

Review type: Full ____ Expedited _X_ **Review date:** 11/14/2014

Risk Factor: Minimal ___X___ Uncertain _____ Greater Than Minimal_____

Approved_____X_____ **Disapproved**_____

Approval Date: 11/14/2014 **Approval Expiration Date:** 11/13/2015

Re-review frequency: (annual unless otherwise stated)

Number of subjects approved: 1000

LSU Proposal Number (if applicable): _____

Protocol Matches Scope of Work in Grant proposal: (if applicable) _____

By: Dennis Landin, Chairman _____

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects"
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. SPECIAL NOTE:
"All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb

Donation: Informed Consent Language

1. Study Title: The effects of fear pheromones on individual perceptions of fear stimuli and individual experiences of relational conflict
2. Site: Louisiana State University and Agricultural and Mechanical College
3. Investigators: The following investigators are available for questions about this study, M-F, 10:00 a.m.- 6:00 p.m.
   Laura Hatcher (334)319-2963
4. Purpose: The purpose of this study is to determine whether the sweat generated while an individual is afraid (fear pheromones) influences how other individuals perceive the world and how other individuals interact with their relational partners.
5. Subjects: Individuals below the age of 18 are not permitted to participate in this study. Additionally, pregnant women are not permitted to participate in this study. Participants are asked not to wear deodorant on the day of the study.
6. Number: 100
7. Procedures: This part of the study seeks sweat donations. The study will take place in three parts. During the first part, you will be asked to answer basic demographic questions as well as questions about your fears and fear responses. During the second part, you will have small cotton pads affixed to you underarms. While accompanied by a researcher, participants will sit or stand outside until they have begun to sweat. Once perspiration has been achieved, the cotton pads will be removed and stored for future use. Participants will then spend five-ten more minutes answering questions about your experience.
8. Benefits: Participants will receive a small amount of course credit for their participation. Additionally, the study may yield valuable information about our subconscious use of the sense of smell.
9. Risks: The risks of this study are minimal. Participants may experience mild social anxiety due to not wearing deodorant the day of the study. Participants will be provided with spray-on deodorant once the study is completed. Subjects may also bring their own deodorant to apply once the study is over. Additionally, if the subject chooses, a notice informing the subjects' peers of their participation in this study will be provided in order to excuse the subject's lack of deodorant. Subjects may choose to give this notice to their peers if they wish. Because experiencing anxiety can cause feelings of stress, participants will be provided with information about the Student Health Center following the study.
10. Refusal: Participants may choose not to participate or to withdraw from this study at any time without penalty or loss of any benefit to which they might otherwise be entitled.
11. Privacy: Results of the study may be published, but no names or identifying information will be included in the publication. Subjects' participation in this study is anonymous. No identifying factors will be collected from subjects and your information will not be linked to the data collected.

12. Signatures:

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Dennis Landin, Institutional Review Board, (225) 578-8692, irb@lsu.edu, www.lsu.edu/irb. I agree to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

Subject Signature:_____ Date: _____

Study 1: IRB Approval

ACTION ON PROTOCOL APPROVAL REQUEST

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu | lsu.edu/irb

TO: Renee Edwards
Communication Studies

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: October 24, 2014

RE: **IRB#** 3556

TITLE: Chemical Communication: The Effects of fear pheromones on human perceptions and interactions (Study 2)

New Protocol/Modification/Continuation: New Protocol

Review type: Full ___ Expedited _X_ **Review date:** 10/23/2014

Risk Factor: Minimal ___X___ Uncertain _____ Greater Than Minimal_____

Approved_____X_____ **Disapproved**_____

Approval Date: 10/23/2014 **Approval Expiration Date:** 10/22/2015

Re-review frequency: (annual unless otherwise stated)

Number of subjects approved: 200

LSU Proposal Number (if applicable): _____

Protocol Matches Scope of Work in Grant proposal: (if applicable) _____

By: Dennis Landin, Chairman _____

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects"
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
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"All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb

Study 1: Informed Consent Language

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   Laura Hatcher (334)319-2963
4. Purpose: The purpose of this study is to determine whether the sweat generated while an individual is afraid (fear pheromones) influences the ways in which other individuals perceive the world and the ways in which other individuals interact with their relational partners.
5. Subjects: Individuals below the age of 18 are not permitted to participate in this study. Additionally, pregnant women are not permitted to participate in this study. Participants are asked not to wear deodorant on the day of the study.
6. Number: 100
7. Procedures: This part of the study is designed to study how people's perceptions may or may not change when exposed to the fear pheromones of others. During the first part of this study, you will be asked to answer questions assessing your typical responses to everyday stimuli. During the next part of the study, a heart-rate monitor will be placed on your finger. You will be given a surgical mask to wear. This mask will contain either fear pheromones or regular sweat. While wearing the mask, you will watch a brief (~7 minutes) YouTube video of a man climbing a cell phone tower. After the video, you will be asked to answer a few questions about how you responded to the video.
8. Benefits: Subjects will receive a small amount of course credit for their participation. Additionally, the study may yield valuable information about our subconscious use of the sense of smell.
9. Risks: The risks of this study are minimal. Participants may experience slight anxiety (elevated heart rate, sweating, feelings of fear, etc.) while watching the video. This anxiety should be no more than one might encounter in their everyday lives. Because experiencing anxiety can cause feelings of stress, participants will be provided with information about the Student Health Center following the study.
10. Refusal: Participants may choose not to participate or to withdraw from this study at any time without penalty or loss of any benefit to which they might otherwise be entitled.
11. Privacy: Results of the study may be published, but no names or identifying information will be included in the publication. Subjects' participation in this study is anonymous. No identifying factors will be linked from subjects to the data being collected.
12. Signatures:

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about

subjects' rights or other concerns, I can contact Dennis Landin, Institutional Review Board, (225) 578-8692, irb@lsu.edu, www.lsu.edu/irb. I agree to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

Subject Signature:_____ Date: _____

Study 2: IRB Approval

ACTION ON PROTOCOL APPROVAL REQUEST

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu | lsu.edu/irb

TO: Renee Edwards
Communication Studies

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: February 19, 2016

RE: IRB# 3681

TITLE: Chemical Communication: The effects of fear pheromones on human perceptions and interactions

New Protocol/Modification/Continuation: New Protocol

Review type: Full __X__ Expedited ____ **Review date:** 2/12/2016

Risk Factor: Minimal ___X_____ Uncertain _____ Greater Than Minimal_____

Approved _____X_____ **Disapproved** _____

Approval Date: 2/12/2016 **Approval Expiration Date:** 2/11/2017

Re-review frequency: (annual unless otherwise stated)

Number of subjects approved: 200

LSU Proposal Number (if applicable):

Protocol Matches Scope of Work in Grant proposal: (if applicable)_____

By: Dennis Landin, Chairman _____

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining (renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. SPECIAL NOTE:

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

Study 2: Informed Consent Language

1. Study Title: The effects of fear pheromones on individual perceptions of fear stimuli and individual experiences of relational conflict
2. Site: Louisiana State University and Agricultural and Mechanical College
3. Investigators: The following investigators are available for questions about this study, M-F, 9:00 a.m.- 6:00 p.m.
   Laura Hatcher (334)319-2963

4. Purpose: The purpose of this study is to determine whether the sweat generated while an individual is afraid (fear pheromones) influences the ways in which other individuals perceive the world and the ways in which other individuals interact with their relational partners.
5. Subjects: Individuals below the age of 18 are not permitted to participate in this study. Additionally, pregnant women are not permitted to participate in this study.
6. Number: 200
7. Procedures: This part of the study is designed to assess how people's interactions with a relational partner may or may not change when exposed to the fear pheromones of others. During the first part of this study, you will be asked to answer questions assessing your typical communication patterns. During the next part of the study, you will be given a surgical mask to wear. This mask will contain one of two types of sweat. This sweat was collected at a previous date and was frozen at 0° F for sanitation. While wearing the mask, you and your partner will be asked to discuss a topic you have disagreed about in the past (the discussion will last for 5 minutes). You will be videotaped during this conversation. However, these recordings will only be used for academic purposes and no identifying information will be recorded or linked to these recordings. After the conversation is over, you will be asked to answer a few questions about how you feel the conversation went.
8. Benefits: Subjects may receive a small amount of course credit (3%) for their participation. Additionally, the study may yield valuable information about our subconscious use of the sense of smell.
9. Risks: The risks of this study are minimal. Participants may experience slight anxiety (elevated heart rate, sweating, feelings of fear, etc.) while having the conversation. This anxiety should be no more than one might encounter in their everyday lives. Because experiencing anxiety can cause feelings of stress, participants will be provided with information about the Student Health Center following the study.
10. Refusal: Participants may choose not to participate or to withdraw from this study at any time without penalty or loss of any benefit to which they might otherwise be entitled.
11. Privacy: Results of the study may be published, but no names or identifying information will be included in the publication. Subjects' participation in this study is anonymous.
12. Signatures:

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Dennis Landin, Institutional Review Board, (225) 578-8692, irb@lsu.edu, www.lsu.edu/irb. I agree to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

Subject Signature:_____ Date: _____

APPENDIX B: INSTRUMENTATION

This appendix presents the various instruments used throughout this project. In parentheses following the main title of each instrument, the alpha reliability for the overall instrument is presented. In parentheses following each item comprising the instrument, the contribution of that item to overall reliability is presented (in the form of what the alpha reliability would have been if the item had been deleted). Scales that were used in both studies (Emotional Contagion Scale) are presented twice (once for Study 1, and once for Study 2). For the Fear Schedule Survey (FSS), items used to create the measure for "fear of heights" are denoted with an asterisk. Alpha reliability information for the measure of "fear of heights" is then presented in a separate section. The remaining fears were not used in the analysis, and so will not be remarked upon in this appendix. For the psychological fear scale and the predicted fear scale used in Study 1, retained items are marked with an asterisk. Alpha-reliability information is only provided for items that were used in the final analysis. For the pre- and post-conflict scales used in Study 2, retained items are marked with an asterisk. Retained items are then arranged into their respective subscales (self-anger and other-anger), and alpha-reliability information is then presented.

Study 1 Instrumentation

Emotional Contagion Scale (α=0.76)

Instructions: This questionnaire consists of 15 items concerning how you think, feel, and act in various situations. Each item has five responses, ranging from 1 (Never) to 5 (Always). Please choose the response that *best* describes you.

1. If someone I'm talking with begins to cry, I get teary-eyed. (α=0.74)
   Never Rarely Usually Often Always
2. Being with a happy person picks me up when I'm feeling down. (α=0.75)
   Never Rarely Usually Often Always
3. When someone smiles warmly at me, I smile back and feel warm inside. (α=0.75)
   Never Rarely Usually Often Always
4. I get filled with sorrow when people talk about the death of their loved ones. (α=0.75)
   Never Rarely Usually Often Always
5. I clench my jaws and my shoulders get tight when I see the angry faces on the news. (α=0.76)
   Never Rarely Usually Often Always
6. When I look into the eyes of the one I love, my mind is filled with thoughts of romance. (α=0.77)
   Never Rarely Usually Often Always
7. It irritates me to be around angry people. (α=0.76)
   Never Rarely Usually Often Always
8. Watching the fearful faces of victims on the news makes me try to imagine how they might be feeling. (α=0.74)
   Never Rarely Usually Often Always
9. I melt when the one I love holds me close. (α=0.76)
   Never Rarely Usually Often Always
10. I tense when overhearing an angry quarrel. (α=0.73)

Never Rarely Usually Often Always

11. Being around happy people fills my mind with happy thoughts. (α=0.73)
    Never Rarely Usually Often Always
12. I sense my body responding when the one I love touches me. (α=0.76)
    Never Rarely Usually Often Always
13. I notice myself getting tense when I'm around people who are stressed out. (α=0.74)
    Never Rarely Usually Often Always
14. I cry at sad movies. (α=0.75)
    Never Rarely Usually Often Always
15. Listening to the shrill screams of a terrified child in a dentist's waiting room makes me feel nervous. (α=0.76)
    Never Rarely Usually Often Always

Source: Doherty, R.W. (1997). The emotional contagion scale: A measure of individual differences. *Journal of Nonverbal Behavior, 21,* 131-154.

Fear Survey Schedule

Instructions**:** The items in this questionnaire refer to things and experiences that may cause fear or other similar, unpleasant feelings. Read each item and decide how much you are disturbed by it nowadays. Then, choose the number that most closely describes how disturbed you feel, using the scale shown below:

	I fear…	**Not at all**	**A little**	**A fair amount**	**Much**	**Very Much**
1.	Open wounds	1	2	3	4	5
2.	Being alone	1	2	3	4	5
3.	Being in a strange place	1	2	3	4	5
4.	Dead people	1	2	3	4	5
5.	Speaking in public	1	2	3	4	5
6.	Crossing streets	1	2	3	4	5
*7.	Falling from a small height	1	2	3	4	5
8.	Being teased	1	2	3	4	5
9.	Failure	1	2	3	4	5
10.	Entering a room where other people are already seated	1	2	3	4	5

*11.	Heights	1	2	3	4	5
12.	People with deformities	1	2	3	4	5
13.	Worms	1	2	3	4	5
14.	Receiving injections	1	2	3	4	5
15.	Strangers	1	2	3	4	5
16.	Bats	1	2	3	4	5
17.	Journeys by train	1	2	3	4	5
18.	Journeys by bus	1	2	3	4	5
19.	Journeys by car	1	2	3	4	5
20.	People in authority	1	2	3	4	5
21.	Flying insects	1	2	3	4	5
22.	Seeing other people injected	1	2	3	4	5
23.	Crowds	1	2	3	4	5
24.	Large open spaces	1	2	3	4	5
25.	One person bullying another	1	2	3	4	5
26.	Tough-looking people	1	2	3	4	5
27.	Being watched working	1	2	3	4	5
28.	Dirt	1	2	3	4	5
29.	Crawling insects	1	2	3	4	5
30.	Sight of fighting	1	2	3	4	5
31.	Ugly people	1	2	3	4	5
32.	Sick people	1	2	3	4	5
33.	Being criticized	1	2	3	4	5

34.	Strange shapes	1	2	3	4	5
35.	Being in an elevator	1	2	3	4	5
36.	Witnessing surgical operations	1	2	3	4	5
37.	Mice	1	2	3	4	5
*38.	Falling from a great height.	1	2	3	4	5
39.	Human blood	1	2	3	4	5
40.	Animal blood	1	2	3	4	5
41.	Enclosed places	1	2	3	4	5
42.	Being rejected by others	1	2	3	4	5
*43.	Airplanes	1	2	3	4	5
44.	Medical odors	1	2	3	4	5
45.	Feeling disapproved of	1	2	3	4	5
46.	Harmless snakes	1	2	3	4	5
47.	Cemeteries	1	2	3	4	5
48.	Being ignored	1	2	3	4	5
49.	Nude men	1	2	3	4	5
50.	Nude women	1	2	3	4	5
51.	Doctors	1	2	3	4	5
52.	Making mistakes	1	2	3	4	5
53.	Looking foolish	1	2	3	4	5

<u>Fear of Heights Subscale.</u> (α=0.80)

1. Falling from a small height (α=0.77)
   1 2 3 4 5

2. Heights (α=0.68)
   1 2 3 4 5
3. Falling from a great height (α=0.71
   1 2 3 4 5
4. Airplanes (α=0.80)
   1 2 3 4 5

Source: Wolpe, J., & Lang, P.J. (1964). A fear survey schedule for use in behavior therapy. *Behavior Research and Therapy, 2(1),* 27-30.

Psychological Fear Response Assessment (α=0.90)

Instructions: This questionnaire consists of thirteen items concerning your emotional reactions to the video you just saw. The responses are on a simple 10-point scale, with 1 representing the lowest level and 10 representing the highest level. Please answer each item while thinking about the video you just watched .

1. I felt scared.* (α=0.85)
   1 2 3 4 5 6 7 8 9 10
2. I felt nervous.* (α=0.84)
   1 2 3 4 5 6 7 8 9 10
3. I felt apprehensive.* (α=0.85)
   1 2 3 4 5 6 7 8 9 10
4. I felt tense.* (α=0.84)
   1 2 3 4 5 6 7 8 9 10
5. I felt excited.
   1 2 3 4 5 6 7 8 9 10
6. I felt disgusted.
   1 2 3 4 5 6 7 8 9 10
7. I felt happy.
   1 2 3 4 5 6 7 8 9 10
8. I felt anxious.* (α=0.94)
   1 2 3 4 5 6 7 8 9 10
9. I felt guilty.
   1 2 3 4 5 6 7 8 9 10
10. I felt proud.
    1 2 3 4 5 6 7 8 9 10
11. I felt sad.
    1 2 3 4 5 6 7 8 9 10
12. I felt ashamed.
    1 2 3 4 5 6 7 8 9 10
13. I felt depressed.
    1 2 3 4 5 6 7 8 9 10

Adapted source: Izzard, C.E. (1972). Discrete Emotions Scale. *ETS,* 1979.

Physical Fear Response Assessment (α=0.88)

Instructions: The following questionnaire consists of nine items assessing your body's reactions to the video you just saw. The responses range from 1 (Completely Disagree) to 5 (Completely Agree). Please choose the answer that best describes how your body reacted to the video you just watched.

1. I felt like I couldn't catch my breath (α=0.86)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

2. I felt like my heart was pounding. (α=0.86)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

3. I felt dizzy (α=0.87)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

4. My palms started to sweat (α=0.89)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

5. The bottoms of my feet started to tingle (α=0.87)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

6. I felt restless (α=0.87)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

7. I felt butterflies in my stomach (α=0.87)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

8. I felt sick to my stomach (α=0.87)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

9. My muscles were tense. (α=0.86)

1	2	3	4	5
Completely Disagree	Disagree	Neither	Agree	Completely Agree

Predictions of the fear responses of others assessment (α=0.86)

Instructions: This questionnaire consists of thirteen items concerning how you think *other people* might respond to the video you just watched. The responses are on a simple 10-point scale, with 1 representing the lowest level and 10 representing the highest level. Think about what you know about other people and choose the response you feel *best* captures how other people would respond to seeing this video.

1. Most people would feel nervous watching this video.* (α=0.75)
   1 2 3 4 5 6 7 8 9 10
2. Most people would feel scared watching this video.* (α=0.79)
   1 2 3 4 5 6 7 8 9 10
3. Most people would feel apprehensive watching this video.* (α=0.92)
   1 2 3 4 5 6 7 8 9 10
4. Most people would feel disgusted watching this video.
   1 2 3 4 5 6 7 8 9 10
5. Most people would feel happy watching this video.
   1 2 3 4 5 6 7 8 9 10
6. Most people would feel anxious watching this video.* (α=0.74)
   1 2 3 4 5 6 7 8 9 10
7. Most people would feel excited watching this video.
   1 2 3 4 5 6 7 8 9 10
8. Most people would feel guilty watching this video.
   1 2 3 4 5 6 7 8 9 10
9. Most people would feel proud watching this video.
   1 2 3 4 5 6 7 8 9 10
10. Most people would feel sad watching this video.
    1 2 3 4 5 6 7 8 9 10
11. Most people would feel ashamed watching this video.
    1 2 3 4 5 6 7 8 9 10
12. Most people would feel depressed watching this video.
    1 2 3 4 5 6 7 8 9 10
13. Most people would feel tense watching this video.* (α=0.74)
    1 2 3 4 5 6 7 8 9 10

Adapted source: Izzard, C.E. (1972). Discrete emotions scale. *ETS,* 1979.

Study 2 Instrumentation

Emotional Contagion Scale (α=0.78)

Instructions: This questionnaire consists of 15 items concerning how you think, feel, and act in various situations. Each item has five responses, ranging from 1 (Never) to 5 (Always). Please choose the response that *best* describes you.

1. If someone I'm talking with begins to cry, I get teary-eyed. (α=0.76)
   Never Rarely Usually Often Always

2. Being with a happy person picks me up when I'm feeling down. (α=0.77)
   Never Rarely Usually Often Always
3. When someone smiles warmly at me, I smile back and feel warm inside. (α=0.75)
   Never Rarely Usually Often Always
4. I get filled with sorrow when people talk about the death of their loved ones. (α=0.76)
   Never Rarely Usually Often Always
5. I clench my jaws and my shoulders get tight when I see the angry faces on the news. (α=0.77)
   Never Rarely Usually Often Always
6. When I look into the eyes of the one I love, my mind is filled with thoughts of romance. (α=0.78)
   Never Rarely Usually Often Always
7. It irritates me to be around angry people. (α=0.78)
   Never Rarely Usually Often Always
8. Watching the fearful faces of victims on the news makes me try to imagine how they might be feeling. (α=0.77)
   Never Rarely Usually Often Always
9. I melt when the one I love holds me close. (α=0.75)
   Never Rarely Usually Often Always
10. I tense when overhearing an angry quarrel. (α=0.77)
    Never Rarely Usually Often Always
11. Being around happy people fills my mind with happy thoughts. (α=0.75)
    Never Rarely Usually Often Always
12. I sense my body responding when the one I love touches me. (α=0.76)
    Never Rarely Usually Often Always
13. I notice myself getting tense when I'm around people who are stressed out. (α=0.76)
    Never Rarely Usually Often Always
14. I cry at sad movies. (α=0.75)
    Never Rarely Usually Often Always
15. Listening to the shrill screams of a terrified child in a dentist's waiting room makes me feel nervous. (α=0.76)
    Never Rarely Usually Often Always

Source: Doherty, R.W. (1997). The emotional contagion scale: A measure of individual differences. *Journal of Nonverbal Behavior, 21,* 131-154.

Relational Satisfaction Scale

Instructions: Please answer the following questions about your relationship with your partner. For each question, assess your level of satisfaction from 1 (lowest level) to 5 (highest level).

1. How well does your partner meet your needs (α=0.73)
   1 2 3 4 5
2. In general, how satisfied are you with your relationship (α=0.71)
   1 2 3 4 5
3. How good is your relationship compared to most (α=0.68)

1 2 3 4 5

4. How often do you wish you hadn't gotten into this relationship (reverse coded) (α=0.77)
   1 2 3 4 5
5. To what extent has your relationship met your original expectations (α=0.72)
   1 2 3 4 5
6. How much do you love your partner (α=0.72)
   1 2 3 4 5
7. How many problems are there in your relationship (reverse coded) (α=0.73)
   1 2 3 4 5

Source: Hendrick, S.S. (1988). A generic measure of relationship satisfaction. *Journal of Marriage and the Family, 50,* 93-98.

Conflict Scale—Pre-Test

Instructions: Answer the following questions thinking about how conversations about the selected topic *typically* go. Use the following scale to answer the questions: 1=Strongly Disagree, 2=Disagree, 3=Neither, 4=Agree, 5=Strongly Agree. Choose the response that *best* captures how your discussions go.

1. I show my partner I care even though we are disagreeing.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

2. My partner shows me they care even though we are disagreeing.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

3. My partner is usually very calm when discussing this issue. (reverse coded)*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

4. I am usually very calm when discussing this issue. (reverse coded)*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

5. I explain my side of the disagreement to my partner.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

6. My partner explains their side of the disagreement to me.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

7. I raise my voice at my partner when talking about this problem*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

8. I often get angry when discussing this problem*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

9. My partner raises their voice at me when we talk about this problem*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

10. My partner often gets angry when discussing this problem*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

11. I show respect for my partner's feelings about this issue.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

12. My partner shows respect for my feelings about this issue.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

13. My partner can get aggressive when talking about this issue*.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

14. I can get aggressive when talking about this issue.*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

15. I suggest a compromise when this issue comes up.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

16. My partner suggests a compromise when this issue comes up.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

17. My partner gets frustrated when we talk about this issue.*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

18. I feel so frustrated whenever this issue comes up*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

19. Whenever this issue comes up, I try to change the subject or avoid talking about it.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

20. Whenever this issue comes up, my partner tries to change the subject or avoid talking about it.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

Pre-Test Self-Anger Subscale (α=0.84)

1. I am usually very calm when discussing this issue (reverse-coded) (α=0.84)
2. I raise my voice at my partner when we talk about this problem (α=0.81)
3. I get angry when we discuss this issue (α=0.77)
4. I can get aggressive when we talk about this problem (α=0.83)
5. I feel so frustrated whenever this issue comes up (α=0.82)

Pre-Test Other-Anger Subscale (α=0.82)

1. My partner is usually very calm when discussing this issue (reverse-coded) (α=0.82)
2. My partner raises their voice at me when we talk about this problem (α=0.73)
3. My partner gets angry when we discuss this issue (α=0.77)
4. My partner can get aggressive when we talk about this problem (α=0.81)
5. My partner gets so frustrated whenever this issue comes up (α=0.83)

Adapted Source: Straus, M.A., Hamby, S.L., Boney-McCoy, S., & Sugarman, D.B. (1996). The revised conflict tactics scales (CTS2): Development and preliminary psychometric data. *Journal of Family Issues, 17(3),* 283-316.

Conflict-Scale—Post-Test

Instructions: Answer the following questions thinking about the conversation you just had in comparison to your typical conversation. Use the following scale to answer the questions:

1=Strongly Disagree, 2=Disagree, 3=Neither, 4=Agree, 5=Strongly Agree. Choose the response that *best* captures how the conversation went.

1. I showed my partner I cared more than I usually do when we disagree.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

2. My partner showed me they cared more than they usually do when we are disagreeing.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

3. My partner was calmer than usual. (reverse coded)*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

4. I was calmer than usual. (reverse coded)*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

5. I explained my side of the disagreement better than I usually do.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

6. My partner explained their side of the disagreement better than they usually do.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

7. I raised my voice at my partner more than I usually do when we talk about this problem.*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

8. I was angrier than I usually am when we discuss this problem*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

9. My partner raised their voice at me more than they usually do when we talk about this problem*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

10. My partner was angrier than they usually are when discussing this problem*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

11. I showed more respect for my partner's feelings than I usually do.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

12. My partner showed more respect for my feelings than they usually do.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

13. My partner was more aggressive than usual*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

14. I was more aggressive than usual.*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

15. I suggested a compromise.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

16. My partner suggested a compromise.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

17. My partner was more frustrated than usual.*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

18. I was more frustrated than usual*

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

19. I wished we could just stop talking about this issue.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

20. I could tell my partner wanted to end this conversation as quickly as possible.

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

Post-Test Self-Anger Subscale (α=0.74)

6. I was calmer than usual. (reverse-coded) (α=0.79)
7. I raised my voice at my partner more than I usually do when we talk about this problem. (α=0.11)
8. I was angrier than I usually am when we discuss this problem. (α=0.67)
9. I was more aggressive than usual. (α=0.67)
10. I was more frustrated than usual. (α=0.64)

Post-Test Other-Anger Subscale (α=0.70)

6. My partner was calmer than usual. (reverse-coded) (α=0.76)
7. My partner raised their voice at me more than they usually do when we talk about this problem. (α=0.81)
8. My partner was angrier than they usually are when we discuss this problem. (α=0.67)
9. My partner was more aggressive than usual. (α=0.71)
10. My partner was more frustrated than usual. (α=0.65)

Adapted Source: Straus, M.A., Hamby, S.L., Boney-McCoy, S., & Sugarman, D.B. (1996). The revised conflict tactics scales (CTS2): Development and preliminary psychometric data. *Journal of Family Issues, 17(3),* 283-316.

VITA

Laura Caitlyn Hatcher received both her bachelor's (2008) and master's (2012) degrees from Auburn University. She joined the academic community of Louisiana State University in 2012 in order to pursue her Ph.D in Communication Studies. During her time in the Department of Communication Studies, she worked on the research teams of Dr. Jim Honeycutt and Dr. Graham Bodie and taught classes including Public Speaking, Interpersonal Communication, Business & Professional Communication, Small Group Communication, and Family/Relationship Communication. She plans to pursue a career in academia, where she can continue to research the more interesting (at least to her) aspects of human communication.