Social Modulation of Pain in Human Subjects:

Effects of Empathy on Pain Perception

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Abstract

The present study examined the effects of two social groups (romantic partners and best friends) on pain perception. Subjects underwent baseline and experimental pain testing days with the same procedure except subjects were primed with watching their romantic partner, best friend, or a stranger in pain during the experimental day. We hypothesized that romantic partners would have the most amount of empathy (measured by a state empathy scale) from watching their partner in pain, followed by best friends, and then strangers. From this hypothesis, we expected romantic partners, followed by best friends and strangers, to show enhanced pain perceptions (measured from unpleasantness and intensity ratings) in a cold pressor test, heat threshold test, and heat suprathreshold test. The specific group hypotheses were not confirmed, however, state empathy ratings were correlated with pain ratings in general, which lead us to believe if our empathy eliciting manipulation had been more effective, we may have seen the expected results.
Social Modulation of Pain in Human Subjects: Effects of Empathy on Pain Perception

Research on social modulation of pain has grown substantially in the past decade. Specifically, watching someone in pain has been noted to activate pain pathways in the observer (Singer et al., 2004). This study will focus on how empathy and social relationships affect one’s pain responses. Before one can fully understand how social factors can affect the physiological and psychological experience of pain, one must first understand how pain is sensed and perceived in the brain.

Pain sensation is part of the larger sensory modality of somatosensation. It is unlike all other sensory modalities. People with pain insensitivity have a much harder time in life than those who are ageusic (unable to taste), blind, deaf, or anosomic (unable to smell). Pain is necessary for survival because people who cannot perceive pain are unable to avoid harmful stimuli and live a life full of injuries. Another difference between pain sensation and other sensory systems is that rather than the perceptual experience of pain diminishing from the constant stimulation, otherwise known as habituation, the stimulus sensitizes the pain receptors so that the perception of pain is heightened (Sternberg, 2007). Damaged cells and tissues in the vicinity of an injury release a variety of chemicals, such as bradykinin, histamine, prostaglandins, leukotrienes, acetylcholine, serotonin, and substance P. Not only do some of them activate nociceptors, but they all decrease the threshold of activation of nociceptors. Therefore, these chemicals will lead to hyperalgesia, or a heightened pain response. These chemicals enhance pain perception, but there are other endogenous chemicals that can inhibit pain perception. In addition, not all painful stimuli necessarily lead the perception of pain. In fact, the sensation and perception of pain have two completely different anatomical and behavioral dimensions (Jackson, Meltzoff, & Decety, 2004).
An important and differentiating aspect of pain is that it has an affective component as well as a sensation component. The affective component of pain is measured by unpleasantness, whereas the sensation component of pain is measured by intensity. In a study by Tolle et al. (1999), subjects underwent pain threshold tests in which a temperature-controlled thermode was attached to four adjacent sites on the volar forearm while a PET scan was taken. After each heat stimulus, a pain rating for intensity and unpleasantness was taken. It was found that the coding for pain intensity was related to the periaqueductal grey area (PAG) and the posterior cingulate cortex, whereas the encoding of pain unpleasantness was related to the posterior sector of the anterior cingulate cortex (ACC). The ACC and anterior insular cortex (AI) are two parts of the limbic system that are important for emotional processing. When one’s insular cortex is lesioned, a condition known as asymbolia occurs; it involves being able to distinguish sharp from dull pain, but not being able to display the appropriate emotional responses to pain. The AI has many different functions: it receives direct projections from the medial, ventral, and posterior thalamic nuclei, it provides information on the internal state of body, and it contributes to the autonomic component of the overall pain response (Jackson, Brunet, Meltzoff, & Decety, 2006). The affective and sensation components of pain merge together in the four stages of pain to create a full pain experience.

Four Stages of Pain

The four stages of pain are sensation, transmission, modulation, and perception. They work collectively in a dynamic process to lead to the final outcomes of a certain amount of pain experience, which is measured by unpleasantness and intensity. Sensation starts from nociception, which is the first stage during the process of going from a noxious stimulus to the
awareness and feeling of physical pain. Although nociception occurs first, and perception last, transmission and modulation continuously work together (Sternberg, 2007).

In nociception, a stimulus, such as extreme pressure, heat, and acids, interacts with pain receptors called nociceptors. Nociceptors are activated from noxious threats to peripheral endings of primary sensory neurons whose cell bodies are located in the dorsal root ganglia and trigeminal ganglia. There are four types: thermal, mechanical, polymodal, and silent. Their receptors are located on skin, in muscles, and in joints. Thermal nociceptors are activated when exposed to temperatures above 45°C and below 5°C, eventually giving rise to the perception of painful heat and cold. Thinly myelinated A\(\delta\) fibers in these nociceptors conduct signals at about 5-30 m/s. The present study will involve thermal stimuli below 5°C as well as above 45°C, so these nociceptors are important to the study. Mechanical nociceptors are activated by intense pressure applied to the skin. Similar to thermal nociceptors, they contain the same fibers, have the same conductance rate, and eventually give rise to the feeling of pain. A\(\delta\) fibers are believed to create the initial severe experience of pain (Sternberg, 2007).

Polymodal nociceptors, however, are made of non-myelinated C fibers that conduct slowly at velocities typically less than 1 m/s. Highly intense mechanical, chemical, or thermal stimuli activate them; therefore, these nociceptors are relevant to the present research. C fibers are believed to contribute to the later achy feeling of pain, rather than the initial sharpness from A\(\delta\) fibers. Both C fibers and A\(\delta\) fibers have been associated with ion conductance through a specific TRP cation channel (called TRPV channels) gated by the vanilloid receptor VR-1. Mutant mice that lack the specific TRP cation channel called TRPA failed to respond to mustard oil (the noxious stimulus found in wasabi), garlic extracts, and the irritant acrolein; this finding illustrates these cation channels’ importance in transducing painful stimuli to lead to pain.
perception (Cesare et al., 1999, as stated in Sternberg, 2007). Other nociceptive afferent fibers are Aα and Aβ fibers; they are wide, myelinated fibers that transmit low-threshold input from mechanoreceptors. Silent nociceptors are different than the other three because they are not stimulated by noxious stimuli. They are located in the viscera and are believed to contribute to the development of secondary hyperalgesia and central sensitization because their firing threshold is greatly reduced from various chemicals and inflammation (Cevero & Laird, 1999).

All the fibers just described are the means by which transmission occurs. Transmission involves the peripheral termini, or free nerve endings, transmitting information gathered from the periphery to the spinal cord, as well as the spinal cord transmitting information to the brain. From the periphery to the spinal cord, transmission follows a pathway from the peripheral nociceptors to the dorsal root ganglion, which is outside of the spinal cord, and then to small short fibers into the dorsal horn of the spinal cord. Pain transmission neurons (PTNs) are in the dorsal horn; they send and receive information to and from the brain (Fields & Basbaum, 1978).

Modulation occurs in the dorsal horn of the spinal cord. The dorsal horn has six distinct layers, and modulation takes place in the superficial ones (lamina I and II). Nociceptors synapse in these superficial layers to PTNs. The output of these PTNs determines the amount of pain information that reaches the brain. Modulation can alter this activity to either enhance or inhibit the perception of pain. Many neurons from lamina I are called nociceptive-specific neurons because they respond exclusively to noxious stimulation and then project to higher brain centers. Other neurons in this layer are called wide-dynamic-range neurons because they respond in a graded fashion to both non-noxious and noxious mechanical stimulation. Lamina II is made up almost entirely of excitatory and inhibitory interneurons that dictate the amount of pain that will be felt. Signals may travel through one of three ascending pathways from the spinal cord
(spinothalamic, spinoreticular, and spinomesencephalic). The spinothalamic pathway goes from the spinal cord, to the ventral posterolateral thalamus, and then to the primary and secondary somatosensory cortices for the sensation of pain to be processed for forming a perceptual experience. The spinoreticular pathway is similar except that before going to the somatosensory cortex, signals pass through the reticular formation, which is associated with arousal and the emotion that goes along with pain; it is part of the limbic system. The spinomesencephalic pathway goes from the spinal cord to the periaqueductal grey area (PAG), a region in the midbrain that has been implicated in descending pain inhibition. Although these pathways interconnect, they are distinct (Fields & Basbaum, 1978). All of these processes, nociception, transmission, and modulation, help lead to the final perception of pain, which takes place in the higher order cognitive areas (Fields & Basbaum, 1978).

**Pain Inhibition**

There are ascending and descending pathways in the brain that allow for the perception of pain to be modified. PTNs can be modulated through non-nociceptive stimuli (Wall & Melzack, 1999). For example, when one rubs an area that has just been injured, pain sensation becomes inhibited. The pain gate control theory describes a mechanism that could make this phenomenon possible. It is hypothesized that excitatory input from the Aδ and C fibers activated from injury converge with the excitatory input from the Aβ fibers that are activated from rubbing. The inputs would converge in Lamina I and V of the dorsal spinal cord. The Aβ fibers also activate inhibitory interneurons in Lamina II of the dorsal spinal cord, which would lead to inhibition of PTNs to alleviate pain. Similarly, this is why electrical stimulation to afferent fibers where pain and injury overlap has been shown to relieve pain (Fields & Basbaum, 1978). Although this
ascending inhibition is important, there has been more research on the descending pathways that can inhibit pain.

The first evidence that there were descending systems that could selectively modulate pain was from the discovery that analgesia, or a lessening of pain, resulted when the PAG was electrically stimulated (Reynolds, 1969). Electrodes were implanted into the PAG in this study. They did not affect pain responses alone because hemostat-applied pressure before and after implantation led to vigorous responses in rats. However, when the electrodes were electrically activated ten days after implantation, the rats underwent surgery of their abdominal skin, muscle, and peritoneum and showed no aversive reactions. It was concluded to be analgesia and not paralysis because loud noises and quick movements in the animals’ visual field elicited startle and struggle responses. Following surgery, brain stimulation was discontinued, and although residual skin analgesia was observed for several minutes, aversive responses to hemostat-applied pressure returned fully within five minutes. This type of analgesia was referred to as stimulation-produced analgesia (SPA). Stimulating the PAG results in analgesia because it is the main source of input to the rostral ventromedial medulla (RVM). The RVM is the major brainstem source of axons that project downward to the dorsal horn of the spinal cord, where PTNs originate. These PTNs are nociceptive. Therefore, when the PAG is stimulated, the PTNs are inhibited, and a lessened pain perception results (Wall & Melzack, 1999).

There are also naturally occurring forms of analgesia. As mentioned before, it is useful for endogenous chemicals released at the site of injury in the body to enhance pain perception so that one knows to retreat from harm. However, it is also sometimes useful for endogenous chemicals to be released in the spinal cord to inhibit pain perception. For example, it would be beneficial for the pain intensity to be lower if one were fighting or fleeing so one could continue
the adaptive behaviors associated with fighting and fleeing. Traumatic injuries that happen
during combat may be perceived as being relatively painless, compared to an injury that happens
when one is not already in stress, such as if boiling water is suddenly spilled on oneself (Carlson,
2004). This lessening of pain is referred to as stress induced analgesia. Stress activates the
hypothalamus, which causes it to release corticotrophin releasing hormone (CRH). CRH causes
an increase in pro-opiomelanocortin gene product, as well as activation of the pituitary to secrete
adrenocorticotropic hormone (ACTH). The gene product stimulates the release of ACTH as well
as beta endorphins, which are endogenous opioids. The connection between stress and pain
regulation is through these endogenous opioids. Opioids inhibit PTNs by binding to opioid
receptors in inhibitory interneurons in spinal cord, to receptors in the descending pathways that
originate in the PAG, and to receptors in higher order brain sites that deal with the emotion of
pain (Meyer & Quenzer, 2005).

Social Modulation of Pain

Higher cognitive brain centers and emotional pathways are very important for modulating
pain perception. There are many social factors that can lead to the enhancement of pain. People
in relationships where one or both partners are in chronic pain have been very useful for
illustrating how the social environment can change the way pain is perceived. Flor et al. (1989)
did a study on the effect significant others had on the pain perception of male and female chronic
pain patients. In one study they found that patients reported greater pain intensity in the presence
of supportive significant others, but not distracting or punishing ones. Spouses who thought their
loved ones (patients) were in more pain were more likely to use supportive responses, such as
massaging their spouses. Distracting ones tried to get their spouses to forget about their pain by
telling them to work on a hobby, and punishing ones would get angry at their spouses for
complaining. These studies did not control for specific relationship factors, though; a follow-up study was conducted using a similar procedure except that three more features were controlled for: gender, living conditions, and marital satisfaction. Subjects filled out the Multidimensional Pain Inventory, which assesses perceived pain intensity and interference with different areas of people’s lives, as well as a Marital Adjustment Scale to assess marital satisfaction. As expected, patients of both sexes in satisfying relationships, but not unsatisfying ones, had their spousal responses predict pain intensity scores so that pain was more intense in satisfied relationships. For males, wives’ responses predicted pain intensity scores, but girlfriends’ responses did not. Interestingly, for the females, the opposite was true: pain intensity scores were more affected by significant others rather than husbands. These results suggest that specific features of social relationships can modulate pain perception in different ways. In our study, we will examine the specific features of empathy, interdependence, closeness, attachment, satisfaction, and commitment to see how they affect pain intensity and unpleasantness ratings.

One study that focused on how empathy in relationships affects pain perception was done by Leonard and Cano (2006). They studied chronic pain and family members using Goubert et al.’s (2005) empathy model (See Figure 1). In this model there are several bottom-up (incoming stimuli) and top-down (observer’s previous knowledge) influences that go into feeling empathy towards another and acting upon it. For example, top-down influences include an observer’s previous experiences with pain and how intense an observer believes another’s pain is. Bottom-up influences include observing facial expressions and contextual clues that would lead one to believe another was in pain. These influences all lead to a sense of knowing what another feels, which results in certain affective and behavioral responses. In Leonard and Cano’s study (2006), depressive symptoms, top-down variables, and bottom-up variables were measured for spouses
observing pain. Believing one’s spouse had greater pain severity was a bottom-up variable that was positively correlated to the observer spouse’s depressive symptoms. Also, spouses who had experienced a lot of pain before were more distressed about their loved ones being in pain. Flor et al. (1989) did a similar study showing that spouses of depressed pain patients had more pain symptoms than spouses of depressed patients without pain. These findings demonstrate how affective responses of spouses observing their significant others in pain are affected by different top-down and bottom-up variables. The theory behind this is that observing a loved one in pain can activate the emotional pain pathways in the brain, which leads to a sensitization reaction, and therefore a lower pain tolerance. For example, fMRI studies indicate that emotional pain pathways are activated while watching someone in pain, but not the sensation pathways (Botvinick et al., 2004).

In Botvinick et al.’s study (2004), videos featuring faces depicting pain were shown to subjects while they underwent fMRIs. This study helps illustrate how psychosocial factors can affect pain perception. The people in the pain videos had chronic shoulder pain and were asked to do a series of movements that would cause them much discomfort. Brow lowering, orbit tightening, and raising of the upper lip were all used as cues that indicate pain since those characteristics have been shown to be representative of pain according to a published Facial Action Coding System (Ekman & Friesen, 1978, as stated in Botvinick et al., 2004). Videos were also shown in which people were making neutral expressions. After subjects watched either the pain or neutral facial expressions, they were given pain threshold tests from a thermode that was designed to rapidly increase and decrease its temperature from 0°C to 50°C. Thermal stimuli was applied to the volar part of the forearm. Results showed greater activation in the ACC and bilateral insula for painful stimuli (above 45°C) compared to non-painful stimuli. Activity in
these areas was also greater when painful faces were viewed beforehand, rather than neutral ones, showing that pain video clips may have sensitized pain pathways. This study gives important insights on how viewing others in pain can activate pain pathways; however, it does not assess actual pain ratings or pain behaviors. It was hypothesized that empathy for the person in pain, which is the subject of the study, is what causes sensitization of the pathways. This sensitization may be brought on by mediated association empathy, which involves the association of a pained person’s situational or expressional cues to an observer’s past painful experiences. However, it may also be brought on by perspective taking empathy; this is when the observers imagine themselves in the pained person’s situation (Hoffman, 2001).

In a similar study, photographs of hands and feet in painful positions, such as distorted and bleeding feet, or neutral ones, such as folded hands, were shown to subjects while they underwent an fMRI (Jackson et al., 2004). Subjects also took Davis’ Interpersonal Reactivity Index (1980); the index measures perspective taking, fantasy, empathic concern, and personal distress. Results showed that subjects rated painful situation pictures as more distressing than the neutral situation pictures. Similar to other studies, the AI and caudal portion of the ACC were significantly more activated while watching the painful situation pictures than the neutral ones. There was also a significant correlation between having higher index scores for distress and more activation in the ACC. However, no threshold or pain ratings were taken to see if participants would actually perceive more pain after watching pictures depicting pain rather than pictures of neutral situations. Perspective taking empathy is believed to be responsible for these results because subjects reported that they assessed how distressing a situation would be by imagining the feet and hands in the photographs were their own. Although watching pained faces of strangers or painful situations of limbs can elicit perspective taking empathy, the concept of
empathy has been greatly debated by many people. In order to understand these studies, one needs to gain a deeper understanding of empathy.

**Empathy**

One aspect of empathy that can be agreed upon by many researchers is that it involves a vicarious affective response to another. Dymond understood empathy to be ‘the imaginative transposing of oneself into the thinking, feeling, and acting of another and so structuring the world as he does’ (p. 127). Kohut (1984) conceptualized empathy as the capacity to think and feel oneself into the inner life of another person. Rogers (1959) gave an in depth account (all as stated in Hakansson & Montgomery, 2003):

> The state of empathy or being empathic is to perceive the internal frame of reference of another with accuracy and with the emotional components and meanings which pertain thereto as if one were the person, but without ever losing the ‘as if’ condition. Thus, it means to sense the hurt or the pleasure of another as he senses it and to perceive the causes thereof as he perceives them, but without ever losing the recognition that it is as if I were hurt or pleased and so forth (pp. 210–211).

This definition focuses on the emotion of the person giving an empathic response. Hoffman (2001), as well, focused more on the emotion of empathic responses than the cognition of them. It was not as important to him for one’s feelings to necessarily be the same as the subject’s feelings, but that those sentiments were created in response to what one perceived the subject’s emotions to be. Hoffman defines the key component of an empathic response to be having a psychological process that make a person have feelings that are more congruent with another’s situation than with his own situation. Hoffman’s broader definition allows not only for empathy to relate to people who show the same affect as a person in pain, but also a different affect that is in response to the person’s pain, such as sadness instead of pain. The purpose of the
The current study is to address the relationship between empathy and pain perception in social relationships.

One theory behind pain threshold decreasing when watching a significant other in pain is that it is an involuntary form of empathy that probably evolved due to the social advantages of empathy. If people do not have pain enhancement and sense danger when another person is in pain, they might not become aware that they should leave the situation, whereas, those that feel more pain would want to leave the situation before something could inflict pain on them. In fact, there has been evidence in animal studies that this automatic empathic response may be hard-wired and deeply preserved. In a recent study (Langford et al., 2006), mouse dyads were placed in one of two conditions: one where they were both injected with .9% acetic acid solution that elicits predictable, observable pain behavior, and another condition in which only one was exposed to the noxious stimulus. The pain behavior was a writhing response. When both mice were exposed to the noxious stimulus, there was considerably more writhing when the mice were cage mates who had been living together for at least two to three weeks than if they were strangers. The same theory of pain pathway activation occurring when a human watches someone in pain applies to when an animal watches a cage mate in pain. Consistent with this animal study, there have been many human studies that illustrate the importance of social factors in pain perception (Flor et al., 1987; Leonard & Cano, 2006). Although mice may only be capable of involuntary empathic responses, humans can show empathic pain responses using higher order cognitive processes. It is important to research how empathy in close human relationships can affect pain perceptions so that more effective treatment options can be created for people in pain.
Singer et al. (2004) studied pain in romantic couples, assuming that if one partner was in pain, empathy would be felt by the other. Brain activity was assessed in the female partner while a painful stimulus was applied to her romantic partner. The partner was seated next to the MRI scanner so that the partner’s right hand could be seen by the subject. Cues were given indicating whether she or her partner would get either a painful or non-painful stimulus. The Balanced Emotional Empathy Scale (BEES) and the Empathic Concern Scale were given to the subjects. High scores on these scales significantly positively correlated with ACC and left AI activation when partners received pain. This study is useful because it shows how naturally occurring empathy in social relationships can affect pain pathways. However, more work needs to be done on how these social relationships affect pain ratings and behaviors.

Many fMRI studies show that pain centers of the brain are activated during social manipulations, such as watching another in pain. One theory for this is that mirror neurons are being fired. Gallese and Goldman (1998) found that when monkeys viewed other monkeys either grasping, holding, tearing, or manipulating objects while electrodes were placed in different motor areas of the subject monkey brain, there were specific neurons in the motor cortex (mirror neurons) that fired. There is evidence that mirror neurons are not solely responsible for the activation of empathic pathways in the brain when one watches another in pain. A significant difference in neuronal firing in the pain regions of the brain was found to depend on the how much empathy one felt in Singer et al.’s (2006) study. The study included the manipulation of the amount of empathy a person would feel by creating an economic game where subjects played against confederates who either played fairly or unfairly. They then had subjects placed in an fMRI machine with a fair confederate on one side of the machine and an unfair confederate on the other side. Using mirrors, the subjects were able to see the hands of the fair and unfair
confederates while they were in the fMRI machine. There were cues indicating whether the subject, fair confederate, or unfair confederate would be receiving a painful or non-painful stimulus. The subjects also had to take the BEES. The results showed that there was significantly more activation in the pain network, including the frontoinsular cortex (FI) and AI, in self painful conditions rather than non-painful conditions. It was found that the higher subjects scored on the BEES, the more activity was observed in the AI and ACC while watching another in pain. There was also a sex difference: while women’s activation in the FI only decreased slightly and insignificantly when watching the unfair confederate receive painful stimuli rather than the fair confederate, males did not show significant activation of the FI for the unfair confederate. This study shows that social conditions can modulate the activation of certain emotional areas of the brain that are normally automatically activated when watching another in pain. Perhaps mirror neuron responses can be inhibited by social factors, such as how one feels about the situation he or she is observing. Mirror neurons could not be solely responsible for the activation in Singer et al.’s study (2004) because subjects’ activation would not vary between fair and unfair players since both types of confederate were in the same situation. Empathy was used as a model in this study because according to the perception-action model of empathy, the observation or imagination of another person in a particular state automatically activates a representation of that state in the observer. Therefore, if one sees another in pain, pain pathways in the person will be activated.

Similarly, Loggia, Mogil and Bushnell (in press) created an empathy-eliciting task for one to partake in before having their pain thresholds tested. Subjects were placed in two groups where they watched a movie of a confederate who either told a really sad personal story (high-empathy group), eliciting empathic concern, or a story that would make others frown upon him
(low-empathy group). Loggia et al. (in press) hypothesized that those who heard the sad story would have higher empathy scale ratings and report more pain intensity and unpleasantness when taking the pain threshold tests. They used four thermal stimuli, two non-painful and two painful. They then showed an eight minute video alternating in two minute segments where the actor was receiving painful or non-painful stimuli. Subjects filled out mood and empathy scales, as well as rated the intensity and unpleasantness of each stimulus received. The high-empathy group felt significantly more empathy towards the confederate than the low-empathy group even though their estimated ratings of the actors’ pain were not different; the high-empathy participants reported more intense and unpleasant pain than low-empathy subjects. The two groups did not differ in sensitivity to non-painful thermal stimuli. This finding challenges the idea that mirror neuron activity underlies empathy because subjects in the two groups were shown exactly the same testing video and rated the actors pain identically, yet there were pain perception differences between the two groups. Since there was no difference in the behavior being modeled, there should be no difference in the activation of mirror neurons across groups; therefore, modulation must have occurred. This study brings about many important insights on how empathy alters pain perception via higher order cognitive processing; however, an unnatural form of empathy is being studied. There needs to be more research on how naturally occurring empathy in social relationships affects pain behaviors and ratings.

*Effects on Empathy: Interdependence, Investments, Attachment, Gender, and Sex*

There are many different aspects of social relationships that could affect how much empathy one would feel while watching a partner or stranger in pain. One aspect that may affect how empathetic people feel towards their partner would be how congruent people feel towards their partners before hand. Part of understanding a partner’s feelings depends on how
interdependent the couple becomes. Interdependence can be defined as the tendency to perceive oneself less as an individual and more as a part of a self-and-partner collective (Agnew, Van Lange, Rusbult, & Langston, 1998). There are theories that perhaps empathy stems from confusion between one’s own self and another’s self. The Inclusion of Other in the Self Scale (IOS) (Aron, Aron, & Smollan, 1992) was designed to tap directly into people’s sense of interpersonal interconnectedness with their partner and the degree of closeness one feels for another. The IOS scale was started as an extension of Aron and Aron’s Self Expansion model. According to Aron and Aron (1997), people are motivated to enter and maintain close relationships to expand the self by including the resources, perspectives, and characteristics of the other in the self. The model focuses on how relationship satisfaction is increased through association of the relationship with self-expansion and that each partner has cognitively included the other in their model of themselves. The IOS has been adapted for many usages in which researchers are interested in how connected one feels towards another person or group of people. It consists of two circles, one representing the self, and one representing another person or group of people. In this study, the scale will be used to measure how close one feels to their romantic partner or best friend. A continuous version of the scale (Le, Moss, & Mashek, in press) was used so that participants could indicate the circles’ degree of overlap from not touching to completely overlapping. There is much research on how empathy can be elicited even when people do not know someone else well, but there is not much research on if a person will feel more empathy towards someone to whom they feel more connected. We believe that closeness would lead to greater empathy, and therefore a sensitization of the emotional pain pathways in the brain when watching a loved one in pain. In a study by Aron, Aron, and Smollan (1992), IOS scales showed more circle overlap for romantic relationships, then friendships, and then family.
Circle overlap was also correlated with centrality of relationship and commitment (Agnew et al., 1998). One of the reasons we believe this is because closeness leads to greater empathic accuracy (Stinson & Ickes, 1992).

Empathic accuracy is the extent to which reading another’s mind is successful. Empathic accuracy has important implications for social modulation and pain because if people have poor empathic accuracy, they may under or overestimate the amount of pain they believe another feels. As mentioned earlier, Goubert’s (2005) model for empathy shows how people’s personal experiences with pain affects not only the amount of pain they perceive another to be in, but also their affective and behavioral responses towards the person in pain. Although cumulative contextual knowledge leads to some empathic accuracy, complete empathic accuracy requires a real knowledge of another, including the person’s present and past circumstances (Gesn & Ickes, 1999). This idea is supported in studies showing that multiple interactions and increased intimacy lead to greater empathic accuracy (Stinson & Ickes, 1992). Strangers have to rely on supposition, analogy, or projection when estimating another person’s emotional state, which can lead to false estimations of the amount of pain one is in. This is why friends have greater empathic accuracy than strangers (Stinson & Ickes, 1992). These findings lead us to hypothesize that empathic responses will vary between friends and strangers. Similarly, one might believe that since romantic partners tend to be more intimate than friends, romantic partners would show greater accuracy (Aron et al., 1992). This helps lead to the conclusion that a more intimate partner’s pain threshold would lower after watching a loved one in pain than a non-intimate partner because of the deeper understanding of the pain the loved one is experiencing. Intimacy not only leads to more interdependence and empathic accuracy, but also an increase in relationship satisfaction and commitment (Agnew et al., 1998).
The interdependence theory (Thibaut & Kelley, 1959) suggests that dependence is greater when a relationship provides preferable outcomes and the outcomes in alternative relationships are low. People who are more dependent, invested, satisfied, and committed to their relationship would probably feel more empathy towards their partners in pain because those partners are so much a part of their lives. Dependence levels refer to the degree to which a person needs his or her partner. Dependence should increase to the degree that satisfaction is high, quality of alternative partners is low, and the individual’s most important needs could not be gratified without the relationship. Therefore, commitment is positively correlated with dependence and satisfaction (Agnew et al., 1998). Commitment implies the intent to persist in a relationship and that there is a psychological attachment to the partner (Rusbult, Drigotas, & Verette, 1994). The more attached partners feel for each other, the more interdependent they become. Therefore, if attachment affects dependence or closeness, and closeness may increase empathetic responses, psychological attachment may enhance empathy as well.

Another factor that may affect a person’s ability to become psychologically attached to another is the person’s attachment style (Collins & Allard, 2001). Attachment styles are working models that involve how the history of one’s experience in relationships (family, friends, and lovers), beliefs about the self, beliefs about others, and attitudes towards relationships will lead to specific behavioral expressions in a relationship. People show varying degrees of being high or low on the two dimensions of attachment styles: avoidance and anxiousness. People low in avoidance and anxiousness tend to describe their most important relationships as happy, friendly, and trusting. People high in avoidance but low in anxiousness have a fear of intimacy. On the contrary, people low in avoidance, but high in anxiousness describe love as an obsession with extreme sexual attraction and jealousy. People high in both anxiousness and avoidance tend to
have emotional highs and lows, want to become close to someone, but are too afraid to actually get involved with another (Hazan & Shaver, 1987). We hypothesized that people with less anxious and avoidant attachment styles would feel interdependent with their partners. This interdependence could lead to an increase in empathetic responses when their partner is in pain. Highly avoidant people do not enjoy becoming intimate with others, and may be less likely to be understand and relate to their partner’s or another’s affective states. Highly anxious people crave intimacy with others, but do not feel interdependent because they are constantly afraid their partner will leave them. Attachment style not only predicts how one will act or feel in a relationship, but also how they act in everyday situations in which their partner is present or absent.

Feeney and Kirkpatrick (1996) examined how the presence of a romantic partner in the room affected women of different attachment styles. Women completed a stressful task twice, once with a male romantic partner in the room, and once without him in the room. Before the task, a baseline measure of diastolic and systolic heart rate and blood pressure were taken. The anxious and non-anxious groups had no significant differences in the partner present condition, but the anxious group had much higher levels of heart rate and diastolic blood pressure in the partner absent condition. Avoidant participants displayed elevated diastolic and systolic heart rates when the partner-absent condition came first, but did not differ from secure participants when the partner present condition came first. Secure and non-anxious groups did not have a difference. Similarly, Kemp and Neimeyer (1999) found that anxious people have more emotional distress towards stress than avoidant people, and avoidant people show more distress than secure people. These studies show that people with certain attachment styles experience more physiological stress than others. People who are more anxious might feel more empathy
towards someone in pain because they tend to become more emotionally distressed in stressful situations, especially in the presence of a romantic partner.

Some other aspects that affect empathy are sex and gender. In heterosexual couples, females consistently show greater empathic accuracy when couples try to infer each others’ thoughts and feelings, especially when obvious trait behavior is being assessed (Ickes, 2000). However, it is hard to know whether or not this can be attributed to biological factors or cultural factors. Females tend to be more feminine and empathic concern for others is a feminine characteristic in the Bem Sex Role Inventory (BSRI) (Bem, 1974). The BSRI characterizes one’s personality as masculine, feminine, androgynous, or undifferentiated using the dimensions masculinity and femininity. It is based on gender stereotypes, so it measures how well one fits into his or her traditional sex role. People who are more feminine may be more empathetic, which may lead to more brain activation when observing others in pain, and therefore lower pain thresholds. In one experiment by Levine and De Simone (1991), women reported higher levels of pain, men gave lower pain ratings to females than males, but there was no difference when both sexes reported their pain ratings to experimenters as the same gender as themselves. This may lead one to believe that perhaps women report having lower pain thresholds because of social expectations. Interestingly, though, there are also biological differences between men and women that would allow for women to feel more pain, rather than just gender effects.

One of the reasons that there are sex differences in pain perception between males and females may have to do with their hormone levels and blood pressure. For example, higher blood pressure in males can lead to hypoalgesia relative to females for thermal stimuli (Fillingim, Maddux, & Shackelford, 1999). However, during the follicular phase, women have reported higher pain thresholds than in other phases of the menstrual cycle (Riley, Robinson, Wise, &
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Price, 1999). Our study investigates sex differences, as well as takes gender into account by having all subjects take the BSRI.

Current Research

In the present study, we examine how social relationships affect empathy. We used the same thermal heat stimuli and task as Loggia et al. (in press), but a different priming video. Previous studies have looked at brain activation when watching another in pain, but not assessed the change in pain behaviors; other studies have noted that social factors can make certain types of people (people with different attachment styles) feel more pain. However, no study has assessed natural forms of empathy in social relationships to see how it changes pain behaviors and ratings, which is what we have done. We tested romantic couples and best friends on their pain thresholds and tolerances before and after watching videos of their partner in pain. We also tested people’s pain thresholds after watching strangers in pain and after watching a nature video. Besides taking empathy measurements before and after the tasks, as other studies have, we gave our participants the Inclusion of Other in Self Scale (IOS), the commitment and satisfaction subscales of the Investment Model Scale, the Attachment Style Scale, the BSRI, Balanced Emotional Empathy Scale (BEES, a trait empathy scale), and a state empathy scale (shorter version of the BEES adapted to assess feelings at that exact moment) to examine how these factors relate to empathy and pain perception.

Hypotheses

This study has five hypotheses:

1) Women in general will have higher trait empathy, state empathy, and pain sensitivity than males.
2) Romantic partners will be the most empathetic towards each other (show highest state empathy scores) after viewing their partner’s pain video; best friends should have the next highest state empathy scores after watching their partner in pain; then subjects who watched a stranger’s pain video would have the next highest state empathy scores. Lastly, control subjects who watched a nature video would have the lowest state empathy.

3) In accordance with the previous hypothesis on empathy, romantic partners will have the most enhanced pain perception, then same sex friends, and then strangers. The control subjects’ pain perception will not be significantly enhanced.

4) Subjects who are more feminine according to Bem Sex Role Inventory will show greater state and trait empathy.

5) Subjects who show higher levels of relationship anxiety, lower levels of relationship avoidance, and are highly committed, satisfied, and interdependent in their relationship will show greater empathy on state empathy scales.

Methods

Participants

Students (n=52) from a small liberal arts college, aged 17-22, were recruited from a campus wide e-mail. There were eight pairs of opposite sex romantic partners, eight pairs of same sex friend partners, and twenty people recruited without a partner. The four groups studied are romantic partners, best friends, people who viewed video clips of strangers (stranger condition), and people who viewed video clips of a nature video (isolated control condition). The romantic partners had to be involved for at least six months. Similarly, the best friends had to be friends for at least six months and matched with someone who there was no possibility of romantic relations based on sexual preference. There were an equal number of male and female
participants, however, due to unexpected error of group assignments, there were an uneven amount of males and females in the stranger and isolated control condition. All participants were given monetary compensation.

**Materials**

A digital video camera was used to videotape subjects while they made a series of facial expressions and underwent pain testing. Videos of the people in the partner conditions were downloaded and edited using iMovie. There was a video taken of a 22 year old male confederate and a 21 year old female confederate for the stranger condition of the experiment. All of the video clips consisted of five twenty second clips of the subjects undergoing pain tests interspersed with segments of three to fours seconds of their pain facial expression. Each video clip was about two minutes long. A two minute clip of a nature video was used for the ten people in the control group.

The TSA II Neuro-Sensory analyzer (Medoc Ltd. Advanced Medical System) was used to administer thermal stimuli. It has a 30 mm x 30 mm thermode that is designed to rapidly change temperature at a rise rate of 1.5°C/second. Its temperature range is from 0°C to 50°C; it is designed so that neither the lowest nor highest temperatures will be able to cause tissue damage. The threshold test involved the thermode starting at a baseline temperature of 32°C, rising until the subject reported feeling pain, and then decreasing back down to the baseline temperature. This procedure was repeated five times and the average threshold was recorded. A suprathreshold test was administered to subjects. It included 16 five second thermal stimulations: eight at the non-painful temperatures of 42°C and 44°C and eight at the painful temperatures of 46.5°C and 48°C. These are the same stimuli used in the Loggia et al. (in press) study.
The cold pressor test consisted of a large bucket with a mesh cylinder inside of it. The space between the outside of the cylinder and the inside of the bucket was filled with ice to the brim and then the whole bucket was filled with water. The temperature of the water was taken before each cold pressor test and was always between $0^\circ$ and $5^\circ$C. The mesh cylinder allowed for the subject to place one’s arm in the bucket without having to physically touch any of the ice. There were two scales taped to the wall directly in front of the participants carrying out the cold pressor test. They were Gracely box scales: one for unpleasantness, which represents the affective component of pain, and one for intensity, which represents the sensation of pain. They ranged from 0 until 20, with 0 being not intense or unpleasant, and 20 being unbearably intense or unpleasant. For the suprathreshold test a 0 to 100 scale was used to rate pain intensity for consistency with the Loggia et al. (in press) suprathreshold tests.

Procedure

The experiment had two slightly different procedures, one for the romantic and best friend partners, and the other for the stranger and control conditions. All four groups participated in three sessions. The first session consisted of participants filling out an informed consent form and several questionnaires, as well as receiving an introduction to the pain testing procedures in order to reduce anxiety associated with undergoing pain on testing days. The procedure of the cold pressor test was explained first and participants were given the option of placing their arm in the bucket of ice water. The heat pain threshold test was explained next. Every participant was then oriented to the heat suprathreshold test. This orientation consisted of participants exposing the volar part of their right forearm for the thermode to be placed upon. The lowest and highest temperature stimuli were given to the participants. They were asked to rate on a scale from 0 to 100 how intense the pain was after each stimulus. They were told the temperature would never
get any hotter than the first temperature they felt and that the same procedure would occur on the testing days except for there would be sixteen stimuli instead of two. The romantic partners and best friends took the Inclusion of Other in the Self Scale, Attachment Style Scale, Bem Sex Role Inventory, the Balanced Emotional Empathy Scale, and two subscales from the Investment Model Scale with respect to their relationships. The strangers and controls took all of these except the IOS and the Investment Model Scale since they were not associated with another person for the purpose of this study.

*Inclusion of Other in the Self Scale*

The IOS (Aron, Aron, & Smollan, 1992) measures a participant’s connection to his or her partner by using a set of Venn-like diagrams each representing different degrees of overlap of two circles. We used the modified continuous version of the scale (Le, Moss, & Mashek, in press) for subjects to overlap the circles to the degree they believed best represented their relationship with their partner. Two measurements were taken from it: the distance between the centers of the two circles and the area of overlap of the circles.

*Attachment Style Scale*

The experiences in close relationships can be measured by the Attachment Style Scale (Brennan, Clark, & Shaver, 1998). It consists of thirty-six statements about how one generally experiences romantic relationships according to two dimensions: avoidance and anxiety. It is scored on a Likert scale from one to seven, 1 being not true, 4 being somewhat true, and 7 being very true. There are eighteen avoidance statements (i.e. “I prefer not to show a partner how I feel deep down.” $\alpha = .91$). There are also eighteen anxiety statements, such as “I worry about being abandoned,” ($\alpha = .92$).

*Bem Sex Role Inventory*
The BSRI (Bem, 1974) has sixty characteristics or descriptors that subjects rate themselves on using a 1 to 7 Likert scale, 1 being never or almost never true and 7 being almost always true. The descriptors are either stereotypically (according to one’s culture) masculine, feminine, or androgynous. For instance, self-reliant is a masculine characteristic, yielding is feminine, and helpful is androgynous ($\alpha = .82$).

**Balanced Emotional Empathy Scale**

The BEES (Mehrabian, 2000) contains thirty statements on how someone emotionally feels in certain situations. Subjects are scored on a 9 point scale from “very strong disagreement” to “very strong agreement.” Fifteen items are worded in a way that depicts low emotional empathy, such as “I hardly ever cry when watching a very sad movie,” ($\alpha = .75$). The other items are worded in a way that depicts high emotional empathy. For example, “I am moved deeply when I observe strangers who are struggling to survive,” ($\alpha = .86$). This balances the effect of some people choosing to generally agree or disagree with most statements.

**Investment Model Scale**

Two subscales were used from the Investment Model Scale (Rusbult, Mertz, & Agnew, 1998): commitment and satisfaction. Commitment level measures one’s intent to persist in a relationship and feelings of psychological attachment. Satisfaction level measures the positive affect one experiences due to a partner fulfilling one’s needs. Partners rate on a 9 point scale from “do not agree at all” to “agree completely” on how each statement describes one’s current romantic relationship. Commitment includes seven items (i.e. “I want our relationship to last a very long time,” ($\alpha = .72$) and the satisfaction subscale includes five items, (i.e. “My relationship is close to ideal,” ($\alpha = .78$).
The second two sessions were either baseline or experimental. Sex effects in the romantic partner condition were controlled for by alternating whether or not a male or female went first for their baseline session. Before videotaping the pain experiments, participants were recorded making seven facial expressions: happy, sad, fear, pain, anger, disgust, and surprise, which are considered to be universal facial expressions. Although only the pain expression was used in our video clips, seven facial expressions were recorded for the purpose of ensuring subjects did not suspect the goal of our testing procedures. Everyone was videotaped making the expressions and undergoing the pain testing for procedural consistency.

Both the baseline and experimental session had the same pain procedure; however, the experimental session began with subjects being primed with their designated two minute video clip. The pain procedure consisted of being assessed for cold pressor pain ratings, heat pain threshold, and heat suprathreshold ratings. The cold pressor test involved subjects placing their left arm in the bucket with their hands open and finger tips touching the bottom for 90 seconds. Every fifteen seconds for those ninety seconds, participants were asked to rate the intensity and unpleasantness using the Gracely Box Scales. The heat threshold was taken next, in which the participants rested their right arm on the arm of a chair and exposed the volar portion of it. The thermode started at 32°C and was placed at the bottom of the person’s forearm. The thermode gradually heated up and participants were told to say stop as soon as the sensation went from being warm or hot to painful. This was done five times, each on a different part of the forearm; the average of those threshold temperatures were taken. The last pain test was the suprathreshold test. The suprathreshold test involves having the sixteen stimuli stated in the material section occur in random order, with a five second rest in between them where the temperature returns back to 32°C. The thermode was placed on a different part of the volar forearm, adjacent to the
one before it, for each stimulus. The subjects verbally rated pain intensity based on the 0 to 100 scale. The participants were told beforehand that they were allowed to remove their arm from the stimulus, whether it is was the thermode or the ice bucket, if they were uncomfortable or the pain became unbearable at anytime. Participants in the baseline session were then dismissed. However, participants in the experimental session had to take the smaller portion of the BEES as a state-empathy scale to judge how empathetic they were feeling at that moment.

Data Analysis

Pain was measured four different ways. The first two ways consisted of summing together the unpleasantness and intensity ratings from the Gracely box scales of the cold pressor test. The third and fourth way pain was measured was from a person’s pain threshold and heat intensity ratings from the suprathreshold tests. A 4 x 2 x 2 mixed factorial was analyzed in which the independent variables were the four different groups and the sex of the participants, and the dependent variables were the experimental and baseline ratings for cold pressor unpleasantness, cold pressor intensity, and heat pain threshold. For the suprathreshold test, the additional independent variable of the four temperatures was added so that a 4 x 4 x 2 x 2 mixed factorial was computed. The Attachment Style Scale, BSRI, BEES, the commitment and satisfaction parts of the Investment Model Scale, and the smaller portion of the BEES for state empathy had all of their scores averaged for a final score. These scores plus the IOS measurements were used in correlational analyses with the pain ratings.

Results

The present study tested a number of hypotheses. The first hypothesis was that women in general would have higher trait and state empathy than males. A One-way ANOVA confirmed this hypothesis for both the BEES (F(1,44) = 19.20, p < .001) and the state empathy scale,
F(1,44) = 7.20, p = .01. (See Graph 1 and Graph 2) The next set of hypotheses involved empathy and pain. Although our experimental manipulation did not produce the expected effects on empathic and pain perceptions, several interesting findings were observed.

**Empathy**

We expected state empathy to be the greatest for romantic partners, then best friends, then strangers, and then controls. However, there was no difference between the groups and their state empathy ratings, (F(3,44) = .16, p = .924). There was a sex effect, as expected, in which females were more empathetic than males, F(1,44) = 6.13, p = .017. There were some interesting sex by partner interactions (F(3,44) = 2.94, p = .044), in which females were more empathetic after viewing their romantic partners in pain than their best friends, but males were more empathetic after viewing their best friends in pain than their romantic partners. (See Graph 3)

We did not expect to see a difference between the four groups for the trait empathy BEES scale, but there was a partner effect (F(1,30) = 6.515, p = .016) in which best friends were more empathetic than romantic partners. There was also a sex effect (F(1,44) = 21.79, p < .001) in which women were more empathetic than men on the BEES.

**Pain**

For the cold pressor test, we expected romantic partners to have the greatest increase in sum of unpleasantness ratings after watching the pain video, best friends to have the next largest increase, then strangers, and the controls not to have a significant difference between the baseline and experimental cold pressor sessions. There was no significant difference in unpleasantness ratings between the two days (F(1,44) = 2.77, p = .103). Though, there was a significant day by partner interaction, F(3,44) = 3.03, p = .039. (See Graph 4) However, none of the baseline unpleasantness scores were significantly different from the experimental unpleasantness scores.
within groups. As expected, there was a sex effect in which women rated pain as being more unpleasant than men, $F(1,44) = 8.72, p = .005$. (See Graph 5)

For cold pressor intensity, we similarly hypothesized that romantic partners would have the greatest increase in sum of intensity ratings after watching the pain video, followed by best friends, then strangers, and for there not be a difference between the baseline and experimental sessions for the controls. There was no day effect ($F(1,44) = 1.53, p = .222$) or day by partner effect ($F(3,44) = .801, p = .50$). However, there was the expected sex effect, $F(1,44) = 4.49, p = .04$, in which women found the pain to be more intense than men. (See Graph 6)

We expected romantic partners to have their pain threshold’s lowered the most on the experimental testing day, followed by best friends, then strangers, and for there not to be a significant difference between the baseline and experimental pain threshold recordings. Similar to other pain tests, there was no day effect ($F(1,44) = .11, p = .741$) or day by partner effect ($F(3,44) = 1.337, p = .275$). The expected sex effect was shown in which women had a lower threshold for pain than men, $F(1,44) = 5.17, p = .028$. (See Graph 7)

For the heat suprathreshold test, we hypothesized that romantic partners would have the most heightened pain responses on the experimental day compared to the baseline, followed by best friends, then strangers, and for there not be a significant difference in the control group between days. We also expected the hotter stimuli to be perceived as more painful than the less hot stimuli. There was no day effect ($F(1,44) = .04, p = .848$) and no day by partner effect ($F(3,44) = .44, p = .728$). There was a strong temperature effect in which subjects rated the higher temperatures more intense than the lower temperatures ($F(3,132) = 156.135, p < .001$). Interestingly, there was also a sex by temperature interaction in which women rated pain significantly greater at the higher temperatures ($46.5^\circ C$ and $48^\circ C$) than the lower temperatures of
42°C and 44°C (F(3,132) = 5.92, p = .001) compared to men. (See Graph 8) As expected, there was also an overall sex effect in which females rated the stimuli as more painful than males did (F(1,44) = 8.592, p = .005).

Pearson coefficient correlations were computed to see if there were any relationship or personality factors that might be associated with the pain or empathy ratings. Masculinity and femininity did not correlate with any pain variables, however, there were some interesting trends. Masculinity correlated negatively with many of the pain ratings, while femininity correlated positively with many of them. As expected, femininity correlated positively with state empathy (r = .528, p < .001), BEES scores, (r = .655, p < .001), and relational anxiety (r = .450, p = .001). Masculinity was negatively correlated with relational anxiety (r = -.290, p = .037). The BEES scores positively correlated with a few of the pain ratings on the experimental day.

Unpleasantness ratings on the cold pressor test were correlated with the BEES at 75 seconds and 90 seconds (r = .294, p = .034; r = .317, p = .022, respectively). The total unpleasantness ratings and the pain ratings on the suprathreshold test at 46.5°C were also correlated with the BEES (r = .287, p = .039; r = .286, p = .04, respectively). The BEES ratings were also correlated with anxiety (r = .323, p = .02) and state empathy (r = .426, p = .002). State empathy was correlated with the experimental suprathreshold pain ratings at 46.5°C (r = .278, p = .046) and 48°C (r = .405, p = .003). Many of the cold pressor ratings were correlated with each other; however, many were not correlated with the heat threshold and suprathreshold ratings. The only suprathreshold rating that was almost always correlated with cold pressor ratings was for the temperature of 46.5°C. Relationship satisfaction was negatively correlated with all of the cold pressor ratings, and significantly for the unpleasantness ratings at 15 seconds (r = -.376, p = .034); there was a negative correlational trend for unpleasantness ratings on the experimental day at 30 seconds (r =
Commitment was correlated with anxiety \((r = .420, p = .017)\). Anxiety was negatively correlated with the intensity ratings of heat pain on the suprathreshold test at 48°C \((r = -.288, p = .038)\) on the experimental day. We also wanted to examine if the length of one’s relationship connected to any of the pain variables. Interestingly, length of relationship was positively correlated with suprathreshold pain intensity ratings on the experimental day at 42°C \((r = .375, p = .038)\), 46.5°C \((r = .396, p = .027)\), and 48°C \((r = .456, p = .01)\), and marginally significantly correlated with ratings at 44°C \((r = .312, p = .088)\). (See Table 1 for compiled correlations)

Our last hypothesis was that people low in avoidance and high in anxiousness would feel more committed to their relationship, more satisfied with their relationship, and show greater empathy on state empathy scales. However, low levels of avoidance and anxiety in relationships did not predict any of those factors. Contrary to our hypotheses, low levels of anxiousness were associated with lower trait empathy, higher pain intensity ratings, more masculinity, lower femininity, and of no relation to satisfaction, interdependence, or state empathy.

Discussion

Our main findings for empathy and pain were not what we hypothesized. We did not find a difference between the different groups (romantic partners, best friends, strangers, and controls) for state empathy. We also did not find a difference between the mean pain ratings in any of the groups between the baseline and experimental testing days; yet, this makes sense since our pain rating hypotheses were based on our state empathy hypotheses. However, we did find that state and trait empathy were both correlated with pain ratings. We also found that length of relationship was positively correlated with pain suprathreshold ratings and that satisfaction was...
negatively correlated with unpleasantness and intensity cold pressor summations. Therefore, if our manipulation to induce empathy was more effective, we may have seen the expected results.

Since there is much literature on how females have higher empathy levels and pain sensitivity than males, we hypothesized that female sex and feminine traits were associated with higher empathy and pain perceptions than male sex and masculine traits. This was confirmed in our study. However, the relationship between the experimental manipulation, empathy, and pain sensitivity was less clear. We originally predicted that the pain sensitivity in the experimental condition compared to the baseline session would be heightened the most for romantic partners, then best friends, then strangers, and not heightened for controls. However, there were not any actual differences between baseline and experimental pain ratings within each of the four groups. In fact, romantic partners’ cold pressor unpleasantness summations went in the opposite direction of becoming less unpleasant on the experimental day. There are a few reasons for why this may have occurred.

One reason is that intensity, saliency, and valence of the pain emotion displayed by the person in the video have a great influence on the intensity of the viewer’s empathic response (de Vignemont & Singer, 2006). Therefore, if the viewer did not think the pain facial expression of the person in pain or the pain behaviors in the video clip video convincingly depicted pain, empathy may not have been elicited. Previous research has shown that observers tend to underestimate the pain of others based on facial behavior (Prkachin et al., 1994, as stated in Danziger, Prkachin, & Willer, 2006). When subjects were asked to make a pain face, many did not know what type of face to make, and their faces did not include all the stereotypical characteristics, such as brow lowering, orbit tightening (which narrows the eye apertures and raises the cheeks), levator tightening (which raises the upper lip and/or produces wrinkles at the
side of the nose), and eye closure. Also, subjects knew that the pain was temporary and that their partner was no longer in pain. A few of the partners laughed when viewing their partner’s pain videos. Laughter could have induced a positive affective state which made romantic partners have an analgesic response. Cogan, Cogan, Waltz, and McCue (1987) performed two experiments to see if laughter had an analgesic effect on pain. The results of their first experiment showed that undergraduate students who were exposed to pain discomfort through induced pressure from an automatic inflation of a blood-pressure cuff after listening to a laughter-inducing narrative had higher pain thresholds than people who listened to a dull narrative or nothing at all. The second experiment compared baseline and experimental pain thresholds of undergraduate women undergoing that same pain discomfort test. They found that pain threshold increased for women who listened to a laughter-inducing narrative, whereas there was not a significant difference in pain thresholds for women who listened to interesting or uninteresting narratives or who did not listen to anything and were just tested twice. This mechanical pressure can be compared to intense thermal stimulation because both mechanical and thermal nociceptors have similar transmitting fibers, conductance rates, and lead to pain perception. Some support for this theory in our study is that relationship satisfaction was negatively correlated with all of the cold pressor ratings, especially for the unpleasantness ones taken right after watching the video clips. Therefore, the more satisfied people were with their romantic partner or best friend, the less unpleasant and intense the pain was from the cold pressor test. This could be because they were happy seeing their partner. How close and committed one felt towards his partner, however, did not affect pain ratings, meaning it was not interconnectedness that affected pain ratings, but positive affect.
Another theory is that watching one’s partner in pain may induce stress, which could initiate the fight or flight response. Watching a loved one in pain can be a very traumatic experience that could activate the hypothalamus. This would eventually lead to the release of endogenous opioids that inhibit pain perception.

We have already considered the bottom up variables of viewing the pain video, but there are also top down variables that affect a person’s empathic responses. If we measured how much previous pain experience each subject had personally underwent, we could examine if partners who felt less empathy towards their partners were exposed to less pain in their lives than those who felt more empathy towards their partners.

It was thought that the pain sensitivities would increase because the subjects would feel empathy for the person in their video who was undergoing the pain tests, but our study did not support this. It has been observed that mice who watch their cage mates in pain and then undergo noxious stimuli (Langford et al., 2006) show enhanced pain behaviors. The theory behind this is that the mice are feeling empathy towards their cage mate and therefore have heightened pain sensitivity. We hypothesized that romantic partners would perceive the most amount of pain because of research that romantic partners are more closely connected to each other than friends (Aron, Aron, & Smollan, 1992). We assumed some empathy would be felt by the strangers, especially by those that were naturally more empathetic towards others. Congruently, the BEES scores positively correlated with the pain ratings on the experimental day; therefore, the cold pressor test was the more unpleasant and the heat pain from the suprathreshold test was more intense depending on how empathetic a person was in general. One problem with our control empathy condition of watching a nature video clip was that some control subjects thought the control nature video was meant to elicit an empathetic response because of a scene in which ants
attacked a ladybug. Therefore, our empathy manipulation may not have been entirely effective and there was not a difference between our four experimental groups in their state empathy ratings. Had our state empathy manipulations worked, we may have seen the expected pain enhancement results because state empathy was positively correlated with heat pain intensity suprathreshold ratings at the higher temperatures. Therefore, the more empathetic one felt after watching the video, the more intense that person perceived the heat pain to be.

We assumed that both romantic partners and best friends would feel more empathy than strangers and controls because in Langford et al.’s study (2006) the hyperalgesic effect only occurred for cage mates that had been living together for at least three weeks; therefore, romantic partners and best friends who have been very close for at least six months should be susceptible to this effect. However, this effect was not seen for intensity or unpleasantness ratings of the cold pressor test, heat pain threshold test, or the heat pain suprathreshold tests. We know that there was a perceived difference in the four heat stimuli in the suprathreshold test such that pain intensity ratings increased as the temperature increased. Interestingly, though, length of relationship for romantic couples and best friends did correlate positively with suprathreshold pain intensity ratings. Therefore, the longer people had been in proximity with their partners, the more intense they perceived the pain stimuli to be. This is congruent with Langford et al.’s (2006) study because perhaps it is not necessarily emotional empathy that causes an increase in pain perception but there is a biological reason concerning more exposure to and habituation with other people that leads to physiologically heightened pain sensitivity. Besides females being more empathetic than males as a reason to cause more pain sensitivity, there are also biological reasons for why females rated the higher temperature heat stimuli significantly more intense than
the lower temperature heat stimuli relative to the male ratings that include hormone levels and blood pressure differences (Fillingim, Maddux, & Shackelford, 1999).

There were also some interesting findings for state empathy, especially considering the small sample size we used. Females were more empathetic after viewing their romantic partners in pain than their best friends, but males were more empathetic after viewing their best friends in pain than their romantic partners. This could be due to the fact that men tend to show a more collective interdependence, whereas women show a more relational interdependence. Gabriel and Gardner (1999) examined gender differences in self-construals (a person’s sense of self in relation to others), emotional experiences, selective memories, and behavioral intentions. In all of these categories, women’s thoughts were based on relationships, whereas men’s ideas were in regard to collective experiences. Therefore, men tend to empathize more with people they are involved in collective groups with, but women have more empathy for people with whom they are in a relationship. Our findings may have been so pronounced because all the male best friend groups, by coincidence, happened to participate on varsity athletic teams with each other.

We hypothesized people with high relational anxiousness and low avoidance would be more empathetic and probably therefore have more pain enhancement in experimental pain tests. However, more relationally anxious people had lower pain intensity ratings on the heat suprathreshold test. This is contrary to evidence that highly anxious people tend to become more physiologically distressed in stressful situations (Kemp & Neimeyer, 1999). The results are also surprising considering that anxiousness is positively correlated with femininity and trait empathy, which are both positively correlated with pain ratings. Concordantly, anxiousness is negatively correlated with masculinity, which correlates negatively with the pain ratings. There must be some other anxiety factor that is negatively related to pain. We also did not find our
hypothesized connections between commitment, satisfaction, and interdependence being associated with more empathy and pain sensitivity.

**Future Directions**

The present findings have many important implications of how pain can be modulated by social factors. If one were to repeat this exact experiment, a larger sample size as well as a different nature video that does not include any violent scenes should be used. It may also be beneficial to have experts trained in the four main aspect of pain facial expressions (brow lowering, orbit tightening, levator tightening, and eye closure) to code the pain videos because then correlations between state empathy, pain ratings, and amount of pain depicted by the person in the video could be correlated. Also, our state empathy scale may not have explicitly tested one’s empathy towards the object of the video as best it should. More direct instructions on empathy towards the object of the video rather than just how one felt at that moment should have been given. One way to elicit more empathy could be to not use a video camera, but actually have people come into lab in pairs. This may be harder to schedule and within subjects comparisons could not be made. Nevertheless, research on attachment styles and having a partner physically present suggests that more prominent effects may be observed in partners if they watch each other in person (Feeney & Kirkpatrick, 1996).

To test if the positive affect theory is true, a positive and negative affect scale should be used in addition to the state empathy one. The positive and negative affect scales would be useful in learning if laughing and positive affect was induced from watching a loved one or watching something funny because if people watching the stranger video experience positive affect as well, the pain videos are most likely more amusing than we expected them to be.
It would be interesting to see if the sex effect is due to biological or social reasons. There were sex effects in every pain test in which women were more sensitive to the thermal stimuli. If a researcher controlled for masculinity and femininity, the same sex effect may not still occur, as seen in previous studies (Levine & De Simone, 1991).

**Conclusion**

The findings of this study have important implications for how pain can be enhanced or inhibited depending on different social situations. It can be evolutionarily favored to have pain enhanced when watching another in pain so that one can learn to avoid pain-inducing situations. However, it can be helpful for people with chronic pain to have a social system to help alleviate their pain. Our study found that laughter tended to decrease pain sensitization. Therefore, romantic partners and friends of patients with pain could help lessen the patient’s unpleasantness by inducing a positive affect in the patient. This study also found that males were more empathetic towards their best friends than their romantic partners, whereas females were more empathetic towards their romantic partners than their best friends. These sex and gender differences should be looked into more to see how pain therapy should be different for males and females. Our study involved inducing acute pain, but it would be beneficial to test out social manipulations in subjects with chronic pain to see if the same effects occur. Research needs to be continued in the area of how different types of social relationships and social scenes can affect pain sensitivity.
References


Jackson, P.L., Brunet, W., Meltzoff, A.N., & Decety, J. (2006). Empathy examined through the
neural mechanisms involved in imagining how I feel versus how you feel pain.

*Neuropsychologia, 44,* 752-761.


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Goubert’s Model explains the different top-down and bottom-up variables that lead to the full empathetic affective and behavioral responses of a person watching another in pain.
As illustrated in the figure above, female ratings on the BEES are significantly higher than male empathy ratings on the BEES.
Graph 2. Sex Difference on Means from State Empathy Scale

The figure above demonstrates that females have significantly higher state empathy scores on the condensed version of the BEES after watching the priming videos than males.
Graph 3 shows that females tend to have more state empathy after watching a video of their romantic partner in pain than their best friend in pain; whereas, males tend to show more state empathy after watching a video of their best friend in pain than their romantic partner.
The above graph compares the mean unpleasantness summations of the cold pressor test for each of the four groups on baseline day 1 and experimental day 2. There is not a significant increase in pain unpleasantness for the best friends from day 1 to day 2, and romantic partners actually tend to decrease in pain, contrary to our hypotheses. Strangers and controls unpleasantness ratings both increased on the experimental day.
As illustrated in the above figure, females have significantly higher unpleasantness ratings for extreme cold stimuli than males.
Graph 6 shows females find extreme cold stimuli significantly more intense than males perceive them.
Graph 7. Sex Difference on Heat Pain Threshold

The above graph illustrates that females have significantly lower heat pain thresholds than males.
Graph 8. Effect of Sex and Temperature on Heat Pain Intensity Scores

The figure above demonstrates that as the temperature of the heat stimulus increases, so does the amount of pain intensity males and females perceive. Females find the two highest temperatures to be significantly more intense than they found the two lower temperatures relative to how males rate the pain intensity of all four stimuli.
### Table 1. Pain Rating and Social Factor Correlations

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<th>Cold Pressor Intensity</th>
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<th>Pain at 44°C</th>
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<th>Pain at 48°C</th>
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*p < .05.

**p < .01