When Social and Physical Pain Intersect in Humans

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Abstract

Prior research has shown that the distress associated with social exclusion (i.e., social pain) and physical pain share biological and neural substrates. This social-physical pain overlap has spawned a number of hypotheses regarding how both types of pain might interact. The dissertation research reported here employed diverse methodologies to investigate two questions stemming from these hypotheses: 1) what is the effect of social pain on physical pain sensitivity and 2) what is the effect of physical pain on social pain sensitivity?

Pertaining to the first question, Study 1 showed that a socially disconnecting live interaction with a partner led to a decrease in physical pain sensitivity. This result, however, was not replicated in Study 2 using an imagination paradigm to conjure two different types of social exclusion experiences, nor did low levels of social connectedness predict subsequent physical pain levels in a sample of chronic pain patients in Study 3. Pertaining to the second question, pain levels did not predict subsequent reports of social disconnection in the diaries of chronic pain patients in Study 3, nor did participants experiencing capsaicin-induced physical pain report social judgments any different from their pain-free counterparts in Study 4. The reasons for, and meaning of, these findings are discussed in detail. Crucial questions that must be confronted to continue advancement in this area of research and recommendations for future studies are also explored.
Dedication

For my wife, who has made it possible for me to pursue this dream.
Acknowledgments

This work reflects the contributions of many individuals. I appreciate the opportunity to acknowledge them here.

First, a very heartfelt thank you to my supervisor, Geoff MacDonald. Over the past four years, I have learned an incredible amount from him through his consistent and patient guidance. He has helped make the graduate school process more pleasant and rewarding than it might have been otherwise. Many thanks also to my other committee members, Mickey Inzlicht and Adam Anderson. I have not spent as much time with them as with Geoff but I have always appreciated our discussions and have acquired many insights from them.

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# Table of Contents

Dedication .................................................................................................................. iii  
Acknowledgments ...................................................................................................... iv  
Table of Contents ...................................................................................................... vi  
List of Tables ............................................................................................................. xi  
List of Figures ........................................................................................................... xiii  
List of Appendices .................................................................................................... xiv  
Chapter 1 General Introduction .............................................................................. 1  
  1 The Importance of Relationships to Human Health ............................................. 1  
  2 What Is Pain And What Is Its Function? ............................................................. 4  
  3 Social Pain ............................................................................................................ 5  
  4 The Studies .......................................................................................................... 9  
Chapter 2 Study #1 .................................................................................................. 11  
  1 Introduction .......................................................................................................... 11  
  2 Methods ................................................................................................................ 13  
    2.1 Participants ...................................................................................................... 13  
    2.2 Setup .............................................................................................................. 13  
    2.3 Measures and Apparatus ............................................................................... 14  
    2.4 Procedure ....................................................................................................... 16  
      2.4.1 Step 1: Introduction and consent .......................................................... 16  
      2.4.2 Step 2: Calibration .................................................................................. 16  
      2.4.3 Step 3: Pre-manipulation pain test. Substance X cream ....................... 17  
      2.4.4 Step 4: Social manipulation ................................................................. 17  
      2.4.5 Step 5: Post manipulation measures and debriefing .......................... 19
Results

3.1 Manipulation check

3.2 Effects of manipulations on pain intensity and unpleasantness

Discussion

Chapter 3 Study #2

Introduction

Methods

2.1 Participants

2.2 Overview

2.3 Setup

2.4 Measures and Apparatus

2.5 Procedure

3 Results

3.1 Manipulation Check

3.2 Effects of Manipulations on Pain Outcomes

3.3 Did VVIQ Scores and/or Vividness Ratings Moderate the Relationship Between Groups and Pain?

3.4 Effects of the Manipulations on Affect Measures

Discussion

Chapter 4 Study #3
1 Introduction ........................................................................................................................................47

2 Methods ..........................................................................................................................................50

  2.1 Participants ..................................................................................................................................50

  2.2 Measures and Apparatus .............................................................................................................51

      2.2.1 Online diary measures .........................................................................................................51

  2.3 Online Diary System ..................................................................................................................54

  2.4 Procedure ....................................................................................................................................54

      2.4.1 Step 1: Training video ...........................................................................................................54

      2.4.2 Step 2: Questionnaires .........................................................................................................55

      2.4.3 Step 3: Diary entries .............................................................................................................55

      2.4.4 Step 4: Debriefing .................................................................................................................55

3 Results ...............................................................................................................................................56

  3.1 Data reduction ...............................................................................................................................56

      3.1.1 Psychosocial measures .........................................................................................................56

      3.1.2 Pain measures .........................................................................................................................58

  3.2 Pain Conditions .............................................................................................................................59

  3.3 Analytical Strategy .........................................................................................................................60

  3.4 Concurrent Relationship Between Social Factors and Pain Ratings ..............................................62

      3.4.1 Do social factors predict concurrent pain? .................................................................................62

  3.5 Longitudinal Relationship Between Social Factors and Pain Ratings ..........................................63

      3.5.1 Do morning social factors predict evening pain levels? .........................................................63

      3.5.2 Does morning pain predict evening social factors? .................................................................63

      3.5.3 Do evening social factors predict the subsequent morning’s pain levels? .........................64

      3.5.4 Does evening pain predict the subsequent morning’s social factors? .................................65

      3.5.5 Do increases or decreases in social factor levels over the course of the day predict evening pain scores? .................................................................................................................66
4 Discussion .................................................................................................................67
Chapter 5 Study #4.....................................................................................................74
1 Introduction .............................................................................................................74
2 Methods ..................................................................................................................77
  2.1 Participants ........................................................................................................77
  2.2 Measures and Apparatus ....................................................................................77
    2.2.1 Pain stimulus ...............................................................................................77
    2.2.2 Social encounter video ................................................................................78
    2.2.3 Measures .....................................................................................................79
    2.2.4 Cognitive task .............................................................................................81
  2.3 Procedure ...........................................................................................................81
    2.3.1 Step 1: Participant prep, random assignment and informed consent ..........82
    2.3.2 Step 2: Application of cream ........................................................................82
    2.3.3 Step 3: Measures ..........................................................................................83
    2.3.4 Step 4: Rate physical sensations ...................................................................83
    2.3.5 Step 5: Perform diversion tasks .....................................................................83
    2.3.6 Step 6: Rate physical sensations (rating #2) ...............................................83
    2.3.7 Step 7: Application of the heat pad ...............................................................84
    2.3.8 Step 8: Rate physical sensations (rating #3) ...............................................84
    2.3.9 Step 9: Cognitive task ..................................................................................84
    2.3.10 Step 10: Rate physical sensations (rating #4) .............................................84
    2.3.11 Step 11: Watch video ..................................................................................84
    2.3.12 Step 12: Provide social judgments ..............................................................85
    2.3.13 Step 13: Rate physical sensations ...............................................................85
    2.3.14 Step 14: Debriefing .....................................................................................85
3 Results .....................................................................................................................85
## List of Tables

<table>
<thead>
<tr>
<th>Table #</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2.1</td>
<td>Participant sex across groups.</td>
<td>20</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Effects of experimental condition on pain intensity and unpleasantness ratings.</td>
<td>21</td>
</tr>
<tr>
<td>Table 3.1</td>
<td>Participant sex and age ranges across groups</td>
<td>35</td>
</tr>
<tr>
<td>Table 3.2</td>
<td>Effects of Time and Group on affect measures.</td>
<td>40</td>
</tr>
<tr>
<td>Table 4.1</td>
<td>Chronic pain sample demographics summary.</td>
<td>51</td>
</tr>
<tr>
<td>Table 4.2</td>
<td>Age and pain duration for participants who did versus those who did not complete the study.</td>
<td>56</td>
</tr>
<tr>
<td>Table 4.3</td>
<td>Diary items comprising each of the four factor psychosocial factors captured in diaries.</td>
<td>57</td>
</tr>
<tr>
<td>Table 4.4</td>
<td>Correlation among the four psychological factors, and emotional closeness and wellbeing.</td>
<td>58</td>
</tr>
<tr>
<td>Table 4.5</td>
<td>Pain conditions mentioned by participants in the chronic pain sample.</td>
<td>60</td>
</tr>
<tr>
<td>Table 4.6</td>
<td>Parameter estimates for a concurrent multilevel model with pain as outcome measure and psychological measures entered simultaneously as predictors.</td>
<td>62</td>
</tr>
<tr>
<td>Table 4.7</td>
<td>Parameter estimates for a lagged multilevel model with morning psychological factors as predictors, and evening pain as the outcome.</td>
<td>63</td>
</tr>
<tr>
<td>Table 4.8</td>
<td>Parameter estimates for a lagged multilevel model lagged analysis regressing each of the evening psychological factors on morning pain.</td>
<td>64</td>
</tr>
<tr>
<td>Table 4.9</td>
<td>Parameter estimates for a lagged multilevel model with evening psychological factors as predictors and morning pain measures as outcomes.</td>
<td>65</td>
</tr>
<tr>
<td>Table 4.10</td>
<td>Parameter estimates for lagged multilevel model with evening pain as the predictor and morning psychological factors measures as outcomes.</td>
<td>66</td>
</tr>
</tbody>
</table>
Table 4.11  Parameter estimates for a lagged multilevel model with change in psychological factors from morning to evening as predictors and evening pain ratings as the outcome variable.

Table 5.1  Social judgment factors and their component items.
# List of Figures

<table>
<thead>
<tr>
<th>Figure #</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 3.1</td>
<td>Study 2 overall design.</td>
<td>29</td>
</tr>
<tr>
<td>Figure 3.2</td>
<td>Rejection ratings before and after the three experimental treatments.</td>
<td>36</td>
</tr>
<tr>
<td>Figure 3.3</td>
<td>Pain unpleasantness scores across groups at both pre- and post-manipulation pain tests.</td>
<td>37</td>
</tr>
<tr>
<td>Figure 3.4</td>
<td>Sadness ratings before and after the three experimental treatments.</td>
<td>40</td>
</tr>
<tr>
<td>Figure 4.1</td>
<td>Hypothesized relationship between degree of felt social connectedness and change in physical pain</td>
<td>70</td>
</tr>
<tr>
<td>Figure 5.1</td>
<td>Procedural sequence for Study 4.</td>
<td>81</td>
</tr>
<tr>
<td>Figure 5.2</td>
<td>Social judgment ratings across the pain and no-pain groups by participants watching the negative video.</td>
<td>90</td>
</tr>
<tr>
<td>Figure 5.3</td>
<td>Pain x Group interaction on ratings of how pleased character A was judged to be.</td>
<td>91</td>
</tr>
</tbody>
</table>
## List of Appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix A</td>
<td>Connectedness questionnaire</td>
<td>119</td>
</tr>
<tr>
<td>Appendix B</td>
<td>Chronic pain diary questions</td>
<td>120</td>
</tr>
</tbody>
</table>
Chapter 1
General Introduction

Humans are supremely social animals. Social elements play a vital role in almost every aspect of human life. We seek out others on occasions of celebration and during times of sorrow. We live, work, play, learn, explore and develop together. Life’s most precious and most frustrating moments play out in the context of other people. To be alone is among the most frightening, sad, and torturous experiences, and so it is not surprising that isolation is considered one of the worst forms of punishment both in correctional facilities and in communities at large. The immense popularity of social networking services such as Facebook and Twitter, to which millions have shown an almost addictive devotion, exposes the strong urges that people have to connect — to share ideas, experiences and discoveries, to gossip, to seek and provide comfort, commiseration and help — and to enjoy the rewarding feeling that they get from this connection.

1 The Importance of Relationships to Human Health

Given the critical importance of social elements in life, then, it is perhaps not surprising that there is a large and growing body of evidence that people who lack adequate social connectedness suffer numerous adverse effects. For example, socially isolated people are 2-3 times more likely to die within a given period than their more connected counterparts (Seeman, 1996; House, Landis, & Umberson, 1988), tend to exhibit reduced antibody responses to influenza immunization (Pressman, et al, 2005), are more likely to develop a cold after infection with cold viruses (Cohen et al, 1997), and have heightened risk for adverse cardiac events (Ali, et al, 2006; Schmaltz et al, 2007). Loneliness -- the perception of inadequacy in one’s social networks -- has been found to be associated with a broad range of health outcomes including prolonged wound healing time (Hawkley, et al, 2003), impaired immune function response
(Marucha et al, 1998), and heightened stress reactions in response to social interactions, relative to their non-lonely counterparts (Hawkley, Burleson, Berntson, and Cacioppo, 2003). Finally, inadequate social support has been shown to lead to heightened cardiovascular reactivity in response to stressful events (Kamarck et al, 1990; Gerin et al, 1992, Christenfeld & Gerin, 2000; Lee, Suchday, & Wylie-Rosett, 2011), greater atherosclerotic build-up (Knox et al, 2000), reduced natural killer immune function (Esterling et al, 1996; Lutgendorf et al, 2005), and diminished vaccination efficacy (Moynihan et al, 2004; Pressman et al, 2005). From this impressive body of research demonstrating the deleterious impact of social disconnection on health and survival, it is indeed tempting to conjecture that human life depends as much on the integrity of one’s social network as on the organs enclosed within the boundaries of the skin; that ample and quality connections within one's social networks may be as essential to human health as clear arteries, and insufficient or dysfunctional social connections may be as risky as atherosclerosis.

There are scores of ways by which feelings of social disconnection may occur. Social isolation, loneliness, and insufficient social support are three examples. Marital conflict, loss of a loved one through death and a move to a new city in which one has few if any close contacts are others. The program of research described in this dissertation focuses on one particular type of experience: acute experiences of social disconnection. Such experiences occur to all of us and can take many forms: colleagues may not include us in after-hours social gatherings. Emails may go unanswered. People may hush up or leave the room when we enter. A request for a date may be rejected. We may fail to get chosen for a team. Support expected from a friend may not materialize. In each case, an acute episode occurs in which one's sense of connectedness within his or her social network is threatened to some degree.
Acute episodes of social disconnection have been achieved experimentally through methods such as telling participants that, on the basis of a personality test, they will likely live a life alone, informing them that no one among a group of individuals they just met had chosen them to work on a subsequent task, or exclusion from playing a videogame with others. Such treatments have been found to provoke a multitude of mental and physical health effects. Such effects include heightened aggression (Twenge, Baumeister, Tice, & Stucke, 2001), impaired self-regulation (Baumeister, DeWall, Ciarocco, & Twenge, 2005), poorer performance on complex cognitive tasks (Baumeister, Twenge, & Nuss, 2002), diminished decision-making rationality (Twenge, Catanese, & Baumeister, 2002), diminished prosocial behavior (Twenge, Baumeister, DeWall, Ciarocco, & Bartels, 2007), heightened salivary cortisol response (Dickerson & Gruenewald, 2004; Blackhart, Eckel, & Tice, 2007), and slowed heart rate and recovery to baseline (Moor, Crone, & van der Molen, 2010).

Of all health effects, however, there exists evidence that socially excluding experiences share a particularly intimate relationship with pain. The purpose of this dissertation research, then, is to expand what is known about the relationship between socially excluding experiences and physical pain in humans. In the next section, I briefly discuss pain and then present evidence bearing upon the relationship between social exclusion and physical pain.
What Is Pain And What Is Its Function?

Almost everyone has experienced pain. Yet it is remarkably challenging to define. Pain is a mechanism of self-preservation. Its considerable ability to capture attention makes it difficult to ignore, and its aversiveness strongly motivates reactions aimed at its reduction. The International Association for the Study of Pain (IASP) has defined pain as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.” (Merskey & Bogduk, 1994). Thus, pain is an aversive experience, incorporating both affective and sensory elements, and is associated with injury or imminent injury. But what function does pain serve? It has been persuasively argued that pain can be conceptualized as a homeostatic emotion (Craig, 2003a,b). Homeostasis refers to the maintenance of the internal conditions necessary for life through active physiological and behavioral means (Sherwood, 2008). As dehydration induces thirst, which prompts drinking, and elevated carbon dioxide levels induce air hunger, which prompts breathing, imminent or actual injury induces pain, which prompts protective behaviors. Pain is thus a (powerful) motivator compelling action aimed at preventing injury (e.g., when very hot water in the shower prompts rapid withdrawal from the water), or the prevention of further injury and the promotion of healing (e.g., when a sprained ankle motivates protective behaviors) (Craig, 2003a,b). Though pain is typically associated with physical injury, there is a growing body of evidence that pain is also associated with social disconnection. While the occurrence or imminence of physical injury

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1 There are some individuals who are born without the ability to feel pain or who feel a pain sensation but are indifferent to it. They suffer numerous adverse effects, including continual injuries, limb amputations, loss of vision due to infection, and a shortened lifespan (Nagasako, Oaklander, & Dworkin, 2003).

2 There are cases, such as masochism, in which pleasure is derived from pain. However, such cases occur in a minority of individuals and even then under specific sexual contexts (Weinberg, 1987).
can produce physical pain, the occurrence or imminence of social injury can produce social pain (MacDonald & Leary, 2005).

3 Social Pain

People often are heard using phrases to describe relationship troubles that bear a striking similarity to descriptions typically applied to physical injury. For example, people often say they are “broken hearted”, “cut to the core,” “emotionally scarred”, “crushed”, “deeply hurt”, or “wounded” (MacDonald & Leary, 2005). Such phrases seem to imply socially disconnecting experiences can be accompanied by pain-like experiences known as social pain (MacDonald & Leary, 2005).

Research suggests that the notion that social disconnection is painful is not simply a metaphor, with physiological systems involved in the processing of physical pain implicated in the processing of social pain. Shortly after the discovery of the opioid system in the brain, a series of studies by Jaak Panksepp and colleagues showed that the administration of morphine calmed distress cries emitted by socially separated animals (Herman & Panksepp, 1978; Panksepp, Herman, Conner, Bishop, & Scott, 1978; Panksepp, Vilberg, Bean, Coy, & Kastin, 1978; Panksepp, Herman, Vilberg, Bishop, & DeEskinazi, 1980; Panksepp, 1998; but see Winslow & Insel, 1991). An opiate drug well known as a killer of physical pain appeared to also dull social pain. In one study, for example, Herman and Panksepp (1978) segregated infant guinea pigs from their mothers and placed the infants in a pen by themselves for 15 mins each day over a period of 2-3 weeks. Such an involuntary separation from the mother typically provokes distress vocalizations (DVIs) in young animals. When injected with the mu-opioid agonist morphine sulfate, however, the isolated guinea pigs emitted significantly fewer DVIs compared to animals...
given a saline injection, while having no effect on overall activity. The effect was dose dependent with higher doses of opioids leading to fewer DVs. These results were subsequently replicated in several studies (Herman & Panksepp, 1978; Panksepp, Herman, Conner, Bishop, & Scott, 1978; Herman & Panksepp, 1981; Panksepp, 1998; Keverne, 1997) and with different animals, including rats (Carden, Hernandez, & Hofer, 1996; Carden & Hofer, 1990b; Kehoe & Blass, 1986a; Kehoe & Boylan, 1994), primates (Kalin, Shelton, & Barksdale, 1988; Keverne et al, 1989), dogs (Panksepp, Herman, Conner, Bishop, & Scott, 1978), and birds (Panksepp, Vilberg, Bean, Coy, & Kastin, 1978). Panksepp conjectured that systems mediating both physical and social pain overlapped and since socially complex mammals appeared relatively recently in evolutionary history, the social distress system may have "piggybacked" onto the more evolutionarily ancient physical pain system to signal social disconnection (Panksepp, 1998).

That social disconnection can be painful would seem sensible from an evolutionary perspective. As discussed earlier, human survival depends heavily on close connections with others. Throughout the course of our evolutionary history, those who felt pain associated with ostracism, rejection, and loneliness would have been more likely to seek to repair this disconnection. Social pain would thus be adaptive as it would prevent straying from the pack, oblivious to the dangers that such social disconnection presented. The apparent biochemical overlap revealed in Panksepp’s studies implies that a neural overlap is likely, but brain imaging is necessary to more directly investigate whether socially injurious events lead to neural responses that are similar to those occurring following physical injury.

Beginning in 2003, a series of fMRI neuroimaging studies appeared, offering this more direct evidence. In a study by Eisenberger, Lieberman and Williams (2003), participants were told that
they would be participating in a video game ("CyberBall") that involved taking turns tossing a ball to two other participants over the Internet while having their brains scanned. In fact there were no others and participants played against a computer pre-programmed to either exclude participants part way into the game or not. Compared to those who were not excluded, the excluded participants showed increased activity in the dorsal anterior cingulate cortex (dACC), insular cortex (IC), and right ventrolateral prefrontal cortex (RVPFC). They also found that self-reported distress was positively associated with greater activity in the dACC and less activity in the RVPFC. Since the dACC has been shown to be involved in acute physical pain processing (Lee & Tracey, 2010; Tracey & Mantyh, 2007; Rainville, 2002), the researchers suggested that their results indicate an overlap in the neural circuitry serving both physical and social pain.

Later studies would largely corroborate the Eisenberger et al (2003) results. For example, using a different method of inducing feelings of social exclusion, Burklund, Eisenberger, and Lieberman (2007) exposed participants to brief video clips of disapproving, angry and disgusted facial expressions in young, healthy adults while scanning their brains. The disapproval faces in general provoked no greater (or lesser) levels of dACC activity than the other two facial expressions, although there was a positive correlation between a measure of rejection sensitivity and dACC activation (but not other limbic areas), as well as reduced activation in the ventro-medial PFC (VMPFC; a region that has been associated with the regulation of responses to threatening situations). Thus, facial expressions of disapproval (presumably reflecting rejection threat) did not lead to any neural effects that distinct from the other facial expressions, but the significant correlation nonetheless suggests a relationship between the two types of pain. Eisenberger and colleagues found this relationship in another study. Eisenberger, Gable, and Lieberman (2007) asked participants to keep a diary of how connected and accepted they felt
during social interactions throughout the day over the course of 10 days. Subsequently, participants’ brains were fMRI scanned while playing Cyberball. Individuals who showed greater activity in the left dACC, bilateral amygdala and left periaqueductal gray (PAG) during Cyberball play reported significantly higher levels of distress during daily social interactions. Finally, DeWall et al (2010) found that participants who took acetaminophen (a physical pain analgesic) for 3 weeks showed reduced activity in the dACC and bilateral anterior insula in response to Cyberball exclusion. Thus, activity in regions of the brain typically implicated in physical pain processing, predicted levels of day-to-day social distress.

The extant fMRI studies investigating neural overlap between social rejection and physical pain have found that social rejection manipulations have provoked activity only in those brain regions linked to the affective component but not the sensory component of pain. But Kross et al (2011) have pointed out that this finding may be the result of insufficient stimulus intensity. To test their hypothesis, they asked individuals who had recently experienced an unwanted break up with a romantic partner to view photos of their ex-partner and to think about the rejection. Brain activity captured during these sessions was contrasted against activity occurring during a physical pain task. Both types of experiences led to increased activity in brain regions associated with the affective component of physical pain (anterior insula, dACC) but also in regions linked to the sensory component of pain (thalamus, dorsal posterior insula [dpINS] right parietal opercular/insular cortex [OP1]) contralateral to the site of stimulation.

One of the limitations of such imaging studies is that the neural regions of activity linked to social exclusion are also known to be involved in other nonpain-related functions. It is possible, therefore, that the involvement of these areas reflect operations that have little to do with pain. To address this question of pain specificity, Kross et al (2011) analyzed the results of 524
published studies of physical pain in order to compare the frequency with which the presence of physical pain is associated with activity in the dpINS and OP1, against the frequency with which activity in these brain regions is associated with general mood and non-pain related tasks such as long-term memory encoding/retrieval, attention switching or working memory. The researchers found that the probability that a study involved physical pain given activation in bilateral dpINS and OP1 ranged from .74 to .88. Given the pain-specificity of these areas, the fact that dpINS and OP1 became active in response to social exclusion is persuasive evidence that the social distress provoked by social exclusion experiences indeed entail painful elements.

The research reviewed here suggests that there are considerable commonalities among the neural substrates mediating both acute physical and social pain. This neural overlap implies the potential that experiences that impact one type of pain will impact the other type. The four studies that comprise this dissertation research seek to expand what is known about the extent to which social and physical pain experiences are mutually influential.

4 The Studies

The purpose of Studies 1 and 2 is to investigate the effect of relatively commonplace types of social exclusion experiences on physical pain. In Study 1, pain responses were tested both before and after random assignment to a mildly negative social encounter with an experimental confederate. Study 2 employed a design identical to Study 1 but instead asked participants to imagine either explicit or implicit rejection. Study 3 investigated the relationships between social experience and pain in the daily lives of chronic pain patients. People living with various chronic pain conditions were asked to complete electronic diaries recording participants’ most recent social and non-social events as well as pain and affect ratings. The longitudinal nature of
this study enabled the examination of not only whether social experience predicts pain responses but also whether variations in physical pain predict social responses. Finally, the purpose of Study 4 was to more fully examine the effects of physical pain on social perception using controlled experimental methods. A painful capsaicin cream was applied to participants’ forearms and participants were asked to provide social judgments regarding a videotaped interpersonal interaction. Together, the aim of these studies is to enlarge the current body of knowledge on the relationship between social connectedness experience and physical pain.
Chapter 2
Study #1

1 Introduction

The evidence that social distress and physical pain share biochemical and neural substrates encourages the supposition that experiencing one type of pain will have an effect upon the other type. Studies 1 and 2 investigate the question of how socially disconnecting experiences impact physical pain responses.

A sizable body of evidence using animal models has generally found that acute socially disconnecting events such as social isolation, maternal separation and social defeat reliably lead to reduced pain sensitivity, a phenomenon known as stress-induced hypoalgesia (Butler & Finn, 2009) in rats (Puglisi-Allegro & Oliverio, 1983), cows (Rushen, Boissy, Terlouw, & de Passille, 1999) and mice (Siegfried, Frischknecht, & Waser, 1984). The limited evidence involving human participants suggests the effect may generalize to people. In one study, DeWall and Baumeister (2006) asked participants to complete a personality questionnaire and then told some participants that on the basis of the results of their personality test, that there was high probability that they would spend the rest of their lives alone, that any friends they have now would drift away and that though they might marry, the marriages would be short-lived. Other participants were told that they would live an accident-prone life while a third group of participants was told that they would enjoy many rewarding relationships throughout their lives. Immediately before and after receiving the bogus feedback, participants were exposed to a series of painful pressure stimuli applied to the finger. Those in the future alone group exhibited significantly less sensitivity to the pain stimuli, tolerating it for longer periods of time, when compared to their counterparts in the other groups.
The results, however, are not unequivocal. In another study, Eisenberger, Jarcho, Lieberman and Naliboff (2006), asked participants to play Cyberball. Subsequent to the game, a series of painful heat stimuli were administered to all participants and they rated the unpleasantness of each. They found no differences in pain ratings across groups. They did, however, discover a positive correlation between reports of social distress following exclusion and ratings of pain unpleasantness in response to the thermal stimuli: the more distressed individuals felt, the higher were their pain unpleasantness ratings.

Existing human studies examining the relationship between social experience and physical pain have therefore turned up apparently inconsistent findings, making it difficult to draw any general conclusions. In one study (DeWall & Baumeister, 2006), pain inhibition was observed, whereas in two others (Eisenberger et al, 2006, MacDonald, 2008) no reliable analgesic effect was observed. This inconsistency may be due to the contrasting characteristics of the social exclusion manipulations employed in these studies. On the one hand, the life-alone exclusion paradigm used by DeWall and Baumeister (2006) was relatively severe, and it has been found that intensely (versus more mildly) threatening experiences tend to lead to hypoalgesia rather than hyperalgesia (Rhudy & Meagher, 2000; 2003; Rhudy et al, 2008). On the other hand, juxtaposed against the severe nature of the life-alone manipulation, the Cyberball paradigm employed by Eisenberger et al (2006) and MacDonald (2008) appears relatively mild. Finally, both the life-alone and Cyberball treatments represent atypical experiences. Receiving feedback that one will spend one’s life alone, unmarried and with few friends is far removed from everyday experience, as is being suddenly excluded from play for no discernible reason in a very simplistic video game.
To address the inconsistency and questionable ecological validity of past research, studies that employ social exclusion manipulations better reflecting the types of experiences that people encounter in their day-to-day lives are needed. In Study 1, the socially disconnecting experience took the form of a relatively commonplace type of negative social exchange with another person who was portrayed as another participant but was in fact an experimental confederate. I hypothesized that participants exposed to the negative encounter would experience a significant reduction in post-manipulation pain, a change that would not be evidenced in the control conditions.

2 Methods
2.1 Participants
Forty-five participants (27 female) were recruited from the first year psychology participant pool at the University of Toronto and from an online classifieds advertisement. Only individuals reporting no medical conditions or medication use associated with altered pain sensitivity were included in the study. Specifically, participants were asked to excuse themselves (without loss of compensation) if any of the following applied: frostbite or other past trauma to the arms or hands, lupus erythematosus, Raynaud’s Syndrome, arthritis or other large or small joint disease or injury, or the consumption of alcohol, psychoactive drugs, anti-inflammatory medications, or analgesics within the prior 24 hours.

2.2 Setup
In order to minimize demand effects, participants were told that the study was a trial investigating the influence of two topically applied, natural food-derived substances on the perception of experimentally induced pain. They were further informed that after testing the first
substance, they would need to rest before being ready to test the second substance. Participants were told that to help distract them from the first pain experience, we had pre-arranged with the university Student Union to test some methods of helping incoming students get to know each other. Thus, under the guise of a separate study, participants took turns answering a list of personal questions with someone who they thought was another participant. This “other participant” was in fact a research confederate (a trained actress with professional acting experience) who had been intensively coached to behave in one of two standardized ways: cool, standoffish and uninterested or warm, friendly and validating. To create a non-social version of the interaction task, participants in the control condition were asked to think about their answers to the same personal questions in solitude.

2.3 Measures and Apparatus

Pain. A Wagner pressure algometer (Wagner Instruments, Greenwich, CT) was mounted to a stand in order to enable precise control (raising and lowering) of the device and a consistent application of pressure across trials and participants. Pain measurement involving pressure has several advantages, including precise control of stimulus intensity, immediate discontinuation upon participant discomfort or for any other reason, minimal and short-lived after-effects, and minimal anxiety compared to other methods such as electric shock. Pressure algometry has been used in research on social exclusion (DeWall & Baumeister, 2006) and has been shown to provide valid and reliable measures of pain sensitivity (Chesterton, Sim, Wright, & Foster, 2007).

Participants placed their hand palm-side down under the algometer so that the dorsal interosseus muscle of the proximal phalange of one finger was directly under the algometer pad. The algometer was lowered gradually at a consistent rate (5 N/sec) onto the finger. The rubber pad
that is pressed against the skin is soft, does not puncture the skin, and does not leave any lasting effects beyond a ring-shaped impression in the skin that disappears within an hour. Both before and after the experimental manipulation, a pain test was administered. Each pain test consisted first of the application of cream to the middle finger of either the left or right hand (determined randomly) and then the administration of 3 pressure pain stimulus trials delivered to this same finger. Participants rested for 3 mins between trials to allow pain sensitivity to recover. During application of the cream, all participants were told that the cream contained a natural substance that would increase, decrease, or have no impact on pain sensitivity. After allowing about 30 secs for the cream to “take effect” the pain stimulus trials began. For each pain test trial, pressure was applied with the algometer to the finger at a rate of 5 N/sec. to a magnitude previously determined to be “moderately painful” during a calibration procedure (see below for details). Individuals were then immediately asked to judge both pain intensity and unpleasantness of the sensation using an 11-point numeric rating scale from 0 (not at all) to 10 (very much). Pain intensity was specified to participants as “the degree to which the sensation in your finger hurts”, and pain unpleasantness was defined as the “the degree to which the sensation in your finger bothers you”. Internal consistency across trials was high for both pre-manipulation pain measures, (Cronbach’s alpha .91 for pain intensity and .93, for pain unpleasantness) as well as for both post-manipulation pain measures (Cronbach’s alpha .90 for pain intensity and .93 for pain unpleasantness).

Affect. The 20-item Positive and Negative Affect Schedule (PANAS; (Watson, Clark & Tellegen, 1988) was administered immediately before the pre-manipulation pain test and immediately before the post-manipulation pain test. The PANAS consists of 10 items describing positive affect (e.g., strong, inspired, enthusiastic) and 10 items describing negative affect (e.g.,
distressed, hostile, nervous). Participants indicated the degree to which they were experiencing each of the 20 emotions at the current moment on a scale from 1 (very slightly or not at all) to 5 (extremely). Scores for both positive and negative affect were computed by summing the responses to each emotion. Cronbach’s alpha for pre-manipulation positive and negative affect was .87 and .78, respectively. Cronbach’s alpha for post-manipulation positive and negative affect was .90 and .82, respectively.

Connectedness. To verify that our manipulations had the desired effect, participants completed an 8-item questionnaire assessing several components of connectedness. Example items included, “How close do you feel to your partner”, “How similar do you feel to your partner”, and “To what degree do you feel your partner understood you?” For each item, participants responded on a scale of 1 (not at all) to 9 (very much). See Appendix A for a reproduction of the entire questionnaire. This scale proved to have good internal reliability with a Cronbach’s alpha coefficient of .95.

2.4 Procedure

2.4.1 Step 1: Introduction and consent

After a brief wait with another individual who appeared to be a student (the confederate), the experimenter appeared and asked the participant to enter the lab. The participant read an information sheet that explained the nature of the study and then provided informed consent.

2.4.2 Step 2: Calibration

Participants were shown the algometer and its function was explained. Pilot testing showed that there was considerable between-individual variation on what level of pressure was considered painful. Thus, we employed a customization procedure to determine the pressure at which each
participant reported moderate pain. This procedure helps capture changes in pain sensitivity by reducing the potential for floor or ceiling effects. The calibration phase proceeded as follows: Participants placed the proximal phalange part of the ring finger of one of the hands (randomly selected) under the algometer probe. Participants were told that as the algometer was slowly lowered, they would begin to experience the pressure as painful but that the pressure would continue to increase. Participants were asked to state the point at which they deemed the sensation was “moderately painful”. At this point, the pressure reading on the algometer was recorded and the pressure released immediately. This procedure was repeated for a total of 3 trials. The average pressure indicated across trials served as the stimulus intensity for the remainder of the study. Upon completion of the trials, participants rested for 3 minutes.

2.4.3 Step 3: Pre-manipulation pain test. Substance X cream.

Participants were first asked to complete the PANAS questionnaire. Then the experimenter pointed to a jar of cream labeled “Substance X”, and indicated that this substance would be the first of the two substances to be tested. The cream was then applied and pain tested in the manner described in the pain measures section.

2.4.4 Step 4: Social manipulation.

After completion of the final pre-manipulation pain test trial, participants were told the following:

“You’ve now completed testing the first substance, substance X, and we would like to also test substance Y. But before proceeding it is important to rest and to do something that will help you take your mind off the pain stimulus experience in order to allow your pain sensitivity to return to baseline. Therefore, we are
asking everyone to participate in another study that is currently underway. It’s short and should keep your mind off the pain stuff. There should be another participant here now. So if you’ll wait here I’ll go see if the other participant is ready. After you’re both in the room, I’ll give you a document that will explain things in more detail. Ok?”

All participants agreed to this second experiment and engaged in a separate consent process. The experimenter left the room, closed the door, randomly assigned the participant to either the Negative Experience or Positive Experience condition\(^3\), and a few minutes later brought the confederate to the participant at which point the social experience manipulation commenced.

The social exercise was adapted from the Relationship Closeness Induction Task (Sedikides et al, 1999) in which two individuals take turns responding to a series of questions that gradually increase in intimacy. All participants received the same questions in the same order. The instructions for the task were as follows:

“You and your partner will both receive two identical series of questions. We would like each of you to take turns answering the questions. In the process you will hopefully get to know each other. Please be as natural as possible. It may be helpful to check off each question as you finish it on the provided sheet. When you are done, one of you should come to find the experimenter.”

\(^3\) Random assignment to the two experimental groups was achieved by means of a coin flip. At the conclusion of initial data collection, a control group was run in order to be certain the results could be attributed to the negative social interaction. Control participants were, therefore, run separately at a later time.
For participants randomly assigned to the NE condition, the confederate was instructed to act somewhat standoffishly. The confederate accomplished this by means of numerous verbal and nonverbal tactics. Verbal tactics included employing brief responses without being rude or abrupt. Nonverbal tactics included making very limited eye contact and using a closed body posture. For participants randomly assigned to the PE condition, the confederate was instructed to take an interest in participants. Verbal tactics included relating participants’ responses to something in the confederate’s own life (intended to reinforce that the participants and the confederate’s life share similarities of experience), and using affirmative phrases such as “I totally agree,” “I hear you”, “Absolutely true!” where applicable. Nonverbal tactics included warm smiling, leaning forward when the participant was talking, showing genuine concern, and avoiding folded arms, hands in front of face, or other cues indicating lack of interest. Following the exchange, participants completed the manipulation checks.

2.4.5 Step 5: Post manipulation measures and debriefing.

The PANAS was again administered, and a cream from another jar, labeled “Substance Y” was applied to the middle finger of the hand opposite to the one used for the pre-manipulation pain test. Pain measurement proceeded identically to Step 3. Upon completion of the pain trials, participants received a funnel debriefing that probed for suspicions regarding the cover story and

4 Verbal and non-verbal methods of communicating both standoffishness and acceptance were guided by suggestions in a book by Nierenberg and Calero (2004).

5 We realized that some participants assigned to the PE group may feel disappointed upon learning that the social exchange that they enjoyed was not “real”. For this reason, we specifically chose a confederate who genuinely loves to meet and talk to new people and for whom showing an interest in another and quickly establishing rapport comes naturally and is genuine. In fact it was the case that for the NE condition the confederate had to restrain her natural inclination towards warmth and friendliness rather than forcing warmth and friendliness in the PE condition.
manipulations. Immediately afterwards, participants received a full account of the study, had questions/concerns addressed, and then were thanked and dismissed.

3 Results

Responses to the funnel debriefing questions were reviewed. All but one participant believed the cover story about the study investigating the effects of different natural substances on the perception of pain. To avoid the possibility of biased pain reports, this participant’s data were omitted from analyses described here.6

Participant sex across groups is presented in Table 2.1.

<table>
<thead>
<tr>
<th></th>
<th>NE (N)</th>
<th>PE (N)</th>
<th>Ctrl (N)</th>
<th>Total (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Female (N)</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
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<td>Total (N)</td>
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<td>16</td>
<td>15</td>
<td>45</td>
</tr>
</tbody>
</table>

3.1 Manipulation check

To verify that the social manipulation had its desired effect, the average connectedness score reported by participants in the NE group was compared to the average connectedness score reported by those in the PE group. An independent samples t-test revealed that the mean connectedness score was significantly lower for the NE group (4.38, range 2.13-7.13, SD = 1.40) than the PE group (7.38, range 6.00-8.88, SD = .82), t(28) = -7.31, p < .001. Thus the mildly

6 During debriefing four participants indicated some suspicion regarding the social encounter. None of the results differed when analyses were repeated with their data omitted so all analyses reported here include their data.
negative social encounter with the confederate led to significantly lower connectedness ratings than did the positive social encounter, confirming that the social manipulation achieved its aim.\(^7\)

### 3.2 Effects of manipulations on pain intensity and unpleasantness:

To examine the influence of experimental condition on each dependent measure, a 2 x 3 analysis of variance (ANOVA) including one within-participants variable (time: before and after manipulation) and one between participants variable (group: NE, PE, control) was conducted on both pain intensity and pain unpleasantness. For pain intensity, no main effect emerged for time, \(F(1,42)=.44, p=.51, \eta_p^2 = .01\) nor for group, \(F(2,42) = 2.28, p = .12, \eta_p^2 = .10\). The interaction between time and group was significant, \(F(2,42) = 5.13, p = .01, \eta_p^2 = .20\) (see Table 2.2), indicating that the difference in pain intensity ratings between pre- and post-manipulation measures depended on the group to which participants had been assigned.

<table>
<thead>
<tr>
<th></th>
<th>NE</th>
<th>PE</th>
<th>Ctrl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Int (Unpl)</td>
<td>Int (Unpl)</td>
<td>Int (Unpl)</td>
</tr>
<tr>
<td>Pre-manipulation</td>
<td>5.9 (1.90)</td>
<td>4.64 (2.38)</td>
<td>5.02 (1.86)</td>
</tr>
<tr>
<td>Post-manipulation</td>
<td>4.64 (1.37)</td>
<td>3.38 (1.69)</td>
<td>5.29 (1.84)</td>
</tr>
<tr>
<td>Change</td>
<td>-1.26</td>
<td>-1.26</td>
<td>0.27</td>
</tr>
<tr>
<td>(p)</td>
<td>0.006</td>
<td>0.01</td>
<td>0.51</td>
</tr>
<tr>
<td>(d)</td>
<td>.93</td>
<td>.95</td>
<td>-.17</td>
</tr>
</tbody>
</table>

Notes: Mean pain intensity and unpleasantness scores on a scale from 0 (none) to 10 (worst imaginable) both before and after the experimental manipulation across groups (with standard deviations in parentheses). Abbreviations: NE, negative exchange; PE, positive exchange; Ctrl, control group; Int, pain intensity; Unpl, pain unpleasantness. Change scores are highlighted in

\(^7\) No connectedness scores were obtained for the control group since they did not encounter a social experience.
bold and were computed by subtracting post-manipulation pain ratings from pre-manipulation pain ratings. P values represent the statistical significance of the difference between pre- and post-manipulation scores.

A simple effects analysis revealed that those in the NE condition showed a significant decrease in pain intensity from pre- to post-manipulation, $t(42) = -2.92, p = .006$. No difference across time was found for those in the PE group, $t(42) = .67, p = .51$, nor for those in the control group, $t(42) = 1.23, p = .23$ (see Table 2.2). To ensure that pain intensity ratings did not differ across groups before the manipulation, a one-way ANOVA on pain intensity scores was conducted. This analysis revealed no significant differences between groups for pre-manipulation pain intensity scores, $F(2,44) = 1.39, p = .26$.

For pain unpleasantness ratings no main effect for time, $F(1,42) = .07, p = .80, \eta^2_p < .01$ nor for group $F(2,42) = 2.71, p = .08, \eta^2_p = .11$ was found. There was however a significant interaction between time and group, $F(2,42) = 4.77, p = .014, \eta^2_p = .19$, indicating that, like pain intensity ratings, the difference in pain unpleasantness ratings between pre- and post-manipulation measures depended on the group to which participants had been assigned.

A simple effects analysis showed that the NE group reported a significant decrease in pain unpleasantness from pre- to post-manipulation, $t(42) = -2.62, p = .01$. No difference across time was found for those in the PE group, $t(42) = 1.06, p = .29$, nor for those in the control group, $t(42) = 1.23, p = .22$ (see Table 1). As with pain intensity scores, a one-way ANOVA on pre-manipulation pain unpleasantness scores was conducted. This analysis revealed no significant
difference between groups for pre-manipulation pain unpleasantness scores, \( F(2,44) = 1.20, p = .31^8 \).

4 Discussion

As predicted, participants who experienced a mildly negative social exchange reported significantly lower pain intensity and unpleasantness after the encounter relative to baseline, whereas those exposed to the positive exchange or the no-interaction control condition reported no change in pain ratings. These findings are consistent with the earlier research conducted by DeWall and Baumeister (2006). However, whereas DeWall and Baumeister elicited a numbing effect with a strongly disquieting forecast of isolation, the hypoalgesic effect in the current study was provoked with a social stressor that better mimics day-to-day experience.

One potential alternative explanation for our findings is that the lower pain ratings obtained in the NE group were the result of a contrast effect. Physical pain stimuli may simply feel less painful when contrasted against the discomfort arising from a negative social experience. Two points argue against this explanation. First, if the results were due to contrast, there should be a within-cell correlation such that participants who experienced the negative social experience most strongly (i.e., reported feeling least connected) rated the pain as least hurtful. In follow-up analyses, no such relationship was found. Second, if a contrast effect was responsible for the findings, then it should follow that pain stimuli would seem especially painful immediately after a positive social experience. This did not happen.

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8 In separate analyses, it was found that the manipulation had no effect on affect, and controlling for affect did not change the results. In addition, no relationship was found between self-reported feelings of connectedness and reports of pain.
The outcome of this study and that of DeWall and Baumeister (2006) raises the question of the mechanism of social hypoalgesia. Two candidates, feelings of disconnectedness and general negative affect, were ruled out by our results. First, connectedness ratings were not related to reports of pain. Second, controlling for self-reported negative affect did not alter the findings, suggesting that simply feeling bad cannot explain the results, a finding consistent with previous research (DeWall & Baumeister, 2006; Eisenberger et al, 2006; Eisenberger, Lieberman, & Williams, 2003). Nonetheless, some studies have suggested that measures of more specific emotion variables such as shame (Dickerson, Gruenewal, & Kemeny, 2004; Chow, Tiedens, & Govan, 2008; Rhudy & Meagher, 2000) may hold promise for explaining the effects of social exclusion, and thus should be included in future research.

It is also conceivable that the negative social experience elicited affective changes not directly accessible via self-report instruments. One way by which this possibility might be tested is to include a startle reflex assessment. The startle reflex, in response to a sudden loud noise, has been found to be reliably modulated by underlying affective state and is commonly regarded as an objective measure of affect valence independent of self-report measures (Hamm et al, 1993; Lang, Bradley, Cuthbert, 1990; Lang, Bradley, Cuthbert, 1992; Vrana, Spence & Lang, 1988). It has been used as an objective measure of affect valence and magnitude in numerous studies including those including social exclusion manipulations (Downey et al, 2004).

The results of this study are consistent with the notion that even slight social disconnection can be stressful, in turn provoking a physiological reaction akin to that which occurs upon perception of a physical threat, one component of which is hypoalgesia (Chesher & Chan, 1977; Kavaliers, Colwell, & Perrot-Sinal, 1997; Kavliers, 1988; Rodgers & Hendrie, 1983; Wideman, Murphy, & McCartney, 1996). The occurrence of this stress-induced hypoalgesia, wherein the perception of
threat provokes a reduction in pain sensitivity, is well established in animal models and in humans (Butler & Finn, 2009). Although typically linked to physical threats, to the extent that social harm is potentially as perilous to human health as physical harm, the prospect of social harm may similarly induce a hypoalgesic reaction.

In the current study, the positive social encounter was not associated with any changes in pain ratings, a finding that may appear counter to prior research. For example, Brown, Sheffield, Leary and Robinson (2003) had college students perform a cold pressor task with random assignment to various levels of social support. Some forms of social support were related to lower reports of pain. Master et al (2009) found that just looking at photos of a loved one was associated with a reduction in heat-induced pain compared to viewing pictures of strangers or objects. Why, then, did a positive interaction not reduce pain in the current study? One possibility is that, in our study, the positive social stimulus and pain test did not occur simultaneously as they did in the Brown et al (2006) and Master et al (2009) studies. Perhaps the effects of a positive encounter are more fleeting, whereas the effects of a negative exchange linger. Indeed, DeWall and Baumeister (2006) found that a forecast of future belonging did not reduce later pain sensitivity. Another possibility is that the null effect in the current study’s PE condition resulted because the encounter in the current study was with a stranger. The involvement of someone with whom participants had a closer relationship might have had a greater impact. Finally, in much the same way that a hungry person will more enthusiastically receive food than a satiated individual, it is possible that exchanges with strangers, of the kind that occurred in this study, might impact most those who especially crave social connection. Future studies should measure baseline levels of perceived connectedness (e.g., loneliness, social
support) to assess the degree to which such individual differences moderate the effects of social manipulations on the perception of pain.

In sum, this study was the first to demonstrate an analgesic effect in reaction to a mildly negative social interaction of the kind frequently encountered in everyday living. As indicated earlier, social exclusion can take many forms. The type of exclusion manipulated in this experiment entailed a failure to achieve a connection. Participants were provided the task of testing an activity that was allegedly designed to help people get to know each other. For those in the NE condition, the opportunity to connect inherent in this activity was not realized. Another type of disconnection entails a loss of an existing connection. In this case, a degree of connection with another has been established but then an explicit act of rejection severs this connection. These two different forms of social exclusion may have distinct consequences for physical pain. The purpose of the next study is to directly test this possibility.
Chapter 3
Study #2

1 Introduction

In Study 1, participants who experienced the mildly negative encounter with the confederate may have felt a sense of disconnection, but they were not explicitly rejected. The type of exclusion experienced by participants in that study derived more from the failure to achieve a connection than from the loss of connection. This is a distinction that Daniel Molden and colleagues (Molden et al, 2008, 2009) argue has important implications. The type of exclusion provoked in Study 1 is similar to how Molden et al (2009) describe implicit rejection (IR). In this case, one’s poor social standing is conveyed in an indirect manner. Other examples include a lover frequently claiming insufficient time to meet, a stranger being unresponsive while directing attention to others, or a social group continuously failing to acknowledge one’s contributions.

The future alone paradigm used by DeWall and Baumeister (2006) study appears to be another example of this form of social exclusion. Being told that one’s future will be characterized by few satisfying relationships is to confront the prospect of a failure to attain the rewards of connection. In contrast, explicit rejection (ER) communicates one’s poor social standing directly. Examples include a longstanding lover indicating the desire to break up, a stranger being rude and insulting, or a social group denying membership. Each conveys a different type

9 It should be noted that the “life-alone” manipulation employed by DeWall and Baumeister (2006) may also have elements of explicit loss of connection as the feedback specifies that friends will dissipate and marriages will end in divorce. It seems likely, however, that it was the overall message of failure to attain social connection (rather than its loss) that was most salient.
of social failure. ER signals the presence of negative feedback, or a loss of a social connection, and that the chance of connection is diminished. By contrast, IR signals a lack of positive feedback or a failure to gain social connection. Importantly, these two forms of social exclusion generate distinct motivational consequences (Higgins, 1997; Molden et al, 2008, 2009).

Experiencing the failure to gain connection through IR results in feelings of agitation, the motivation to pursue positive outcomes (i.e., promotion), and an enhanced state of eagerness. Experiencing the loss of connection through ER, on the other hand, results in feelings of dejection, the motivation to prevent such outcomes (i.e., prevention), and an enhanced state of vigilance. Promotion motivations have been found to lead to behaviors oriented towards the pursuit of gain, resulting in social approach, whereas prevention motivations have been found to lead to behaviors oriented towards protection from further loss, resulting in social withdrawal.

These distinctions received support in a series of studies conducted by Molden et al (2009). For example, in one experiment, participants were asked to recall a time when they were either explicitly or implicitly rejected and to describe the circumstances, who was responsible for the exclusion, how many people were involved, and what they did immediately following the rejection experience (Molden et al, 2009, Study 2). They found that participants describing an instance of ER tended to report social withdrawal responses (as a means of preventing further social/emotional injury), whereas those who described IR experiences were more likely to report attempting to re-engage in social contact (as a means of promoting social gain).

Study 1 of the current research employed a socially excluding treatment that was closer to an implicit exclusion than an active rejection. The purpose of Study 2 was to attempt to replicate the effects of IR on pain, while comparing these effects to those resulting from ER as well to the effects of a negative, non-exclusion control group. Study 2 employed a paradigm similar to the
one used for Study 1. However, instead of interacting with a confederate, participants were asked
to imagine one of 3 scenarios: IR, ER, or financial hardship (FH). Since the manipulation relies
on individuals’ ability to imagine scenarios, a measure of individual imagination capacity
(VVIQ) was included. Additionally, immediately subsequent to the imagination task, participants
were asked to rate how vividly they believed they were able to visualize their scenario. As in
Study 1, pressure pain ratings were acquired immediately before and after the social
manipulation.

2 Methods

2.1 Participants

Fifty-nine participants (41 female, age range 18-30 years) were recruited from the first year
psychology participant pool at the University of Toronto. Eligibility requirements were the same
as those in Study 1.

2.2 Overview

The overall design of the study is depicted in Figure 3.1 below:

![Diagram](image)

**Figure 3.1.** Study 2 overall design.
Notes: ER = Explicit Rejection, IR = Implicit Rejection, FH = Financial Hardship.
2.3 Setup

This study employed an experimental paradigm essentially the same as the one used for Study 1, the main difference being the substitution of a different social disconnection manipulation. Please see the Methods section of Study 1 for details. Only the points where Study 2 differ from Study 1 will be detailed here.

2.4 Measures and Apparatus

2.4.1 Pain stimuli

The pain stimuli and testing procedure employed in this study were identical to that of Study 1. Internal consistency across trials was high for both pre-manipulation pain measures (Cronbach’s alpha .84 for pain intensity and .89 for pain unpleasantness) as well as for both post-manipulation pain measures (Cronbach’s alpha .81 for pain intensity and .85 for pain unpleasantness).

2.4.2 Measures

Baseline affect. Positive and Negative Affect Schedule – Extended (PANAS-X; Watson & Clark, 1994). To assess baseline affective state, the PANAS-X was administered immediately prior to the pre-manipulation pain test. The PANAS-X consists of 60 emotion-related adjectives that tap into 11 different affective domains: fear, sadness, guilt, hostility, shyness, fatigue, surprise, joviality, self-assurance, attentiveness and serenity. To serve as a manipulation check two additional items were added (and presented at random positions) to the PANAS-X: rejected and excluded. The mean of the responses to these two items provided the measure of pre-manipulation perceived rejection. Participants indicated the degree to which they were currently experiencing each of the emotions on a scale of 1 (very slightly or not at all) to 5 (extremely).
Cronbach’s alpha for pre-treatment fear, hostility, sadness, fatigue, positive affect, and rejection in this study was .85 (6 items), .79 (6 items), .78 (5 items), .78 (4 items), and .90 (10 items), and .63 (2 items) respectively.

Post-treatment affect. Profile of Mood States – Short Form (POMS-SF; Shacham, 1983). The Profile of Mood States (POMS, described below) was administered to assess affective state immediately after the experimental treatment. The POMS-SF consists of 37 emotion adjectives rated on a 5 point scale from 0 (not at all) to 4 (extremely so) that tap into 6 different affective domains: tension-anxiety, depression, anger-hostility, vigor-activity, fatigue, confusion-bewilderment. Only the 5 POMS domains with comparable subscales on the PANAS-X were computed and used in analyses (POMS domain in parentheses): fear (tension-anxiety), hostility (anger-hostility), sadness (depression-dejection), fatigue (fatigue), and general positive affect (vigor). Two additional items – rejection and excluded – were added (and presented at random positions) to the POMS and the responses averaged to provide the post-manipulation measure of perceived rejection. Cronbach’s alpha for post-treatment fear, hostility, sadness, fatigue, positive affect, and rejection in this study was .82 (6 items), .81 (7 items), .86 (8 items), .53 (4 items), .87 (6 items), and .75, respectively.¹⁰

Post-treatment imagination vividness. To assess the clarity with which their scenario was visualized, participants were asked the single question, “how vividly were you able to imagine the scenario?” immediately after completing the imagination task and answered on a scale from 1 (“not at all vividly”) to 7 (“extremely vividly”).

¹⁰ Due to a technical glitch, the fatigued item from the POMS scale was not included in these analyses. The Confusion-Bewilderment subscale from the POMS-SF was omitted from analyses as there was no counterpart scale on the PANAS-X from which to compute a pre- to post-treatment change score.
Prevention-Motivation orientation (PM Scale; Molden et al, 2009). To verify that the two rejection manipulations (ER and IR) effected distinct affective orientations, the PM scale was administered to participants immediately after the experimental manipulation. The prevention-motivation (PM) scale has been used to distinguish prevention-focused from promotion-focused orientation in past research and thus served as a manipulation check. Four items measure agitation (agitated, on edge, uneasy, tense) and 4 items measure dejection (disappointed, discouraged, low, sad). Individuals responded on a 7-point scale from 1 (definitely don’t feel this way) to 7 (definitely feel this way).

Imagination capacity. The Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) is a 16-item instrument designed to measure individual differences in imagination capability. It consists of 4 groups of 4 items in which individuals attempt to imagine the scene described in each item and then rate the vividness of their mental image on a 5 point scale from 1 (Perfectly clear and vivid as normal vision) to 5 (No image at all; you only “know” you are thinking of an object). Examples include “the sun is rising into a hazy sky” and “The overall appearance of [a shop that you often visit] from the other side of the road”.

2.5 Procedure

2.5.1 Step 1: Participant prep, informed consent and questionnaires

Participant preparation was the same as that of Study 1. After providing signed consent, and indicating readiness to proceed, participants were asked to use the computer to complete the
following set of scales: demographics (gender, age range), PANAS-X, UCLA-R, BFNES, and VVIQ in that order.\textsuperscript{11}

2.5.2 Step 2: Calibration and pre-manipulation pain test.

Pain calibration and the pre-manipulation pain test procedures were administered as in Study 1.

2.5.3 Step 3: Social manipulation

Following the pre-manipulation pain test, the computer randomly assigned individuals to one of the 3 conditions: ER, IR, or FH. Individuals randomly assigned to the ER condition were given the following instructions:

“Imagine being rejected by someone whose relationship you value. Imagine that this person states that he or she doesn't like you, doesn't want to be with you, and/or wishes no further contact with you. Immerse yourself in this situation as fully as you can, including what you would think and feel. Imagine it as vividly as possible, as if it was really happening to you. Then type out in detail what you imagined in the box below. Be sure to include your thoughts and feelings. You have 10 minutes. When the time has elapsed, you will automatically be redirected to a final questionnaire.”

Instructions given to those in the IR and FH group are identical except for the first paragraph. For the IR group:

\textsuperscript{11} Though the UCLA-R and BFNES scales were included, none moderated any of the effects reported, and thus are not discussed further.
“Imagine a situation in which you are being ignored by someone whose relationship you value. Perhaps this person never seems to find time for you, is often busy, and/or seems to make excuses when you propose to get together to do things.”

For the FH group:

“How imagine a situation in which you are experiencing severe financial hardship. You’ve graduated from university but cannot get a job for many many months. Meanwhile your huge debt is accumulating and it appears that there's no way out.”

In each case, the narratives typed out by participants were recorded. Immediately after the 10 min interval the computer automatically advanced to the next screen and administered the POMS and the prevention-motivation scale.

After participants completed both questionnaires, the computer thanked them and asked them to wait for the experimenter to return. The experimenter thanked participants for helping out on the other study and told them they would now be able to proceed to test the second cream.

2.5.4 Step 4: Post manipulation pain test and debriefing

The post-manipulation pain test was administered, followed by debriefing, in a manner identical to Study 1.
3 Results

Participant sex and age ranges across groups are presented in Table 3.1.

<table>
<thead>
<tr>
<th>Table 3.1</th>
<th>Participant characteristics.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ER (N)</td>
</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Male</td>
<td>6</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>18-23</td>
<td>11</td>
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<tr>
<td>24-30</td>
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<td>41-50</td>
<td>3</td>
</tr>
<tr>
<td>51-60</td>
<td>–</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>2</td>
</tr>
<tr>
<td>Total (N)</td>
<td>20</td>
</tr>
</tbody>
</table>

3.1 Manipulation Check

Before and after the manipulation, participants reported on how rejected and excluded they felt. The mean of these variables was computed for both the pre- and post-manipulation scores to create a single rejection score. To verify that the imagination exercise had the desired effect, the change in reported feelings of rejection from pre- to post-manipulation was compared among the 3 groups: ER, IR, and FH.

A repeated measures analysis with pre- and post-treatment Rejection ratings as the within-person variable and Group as the between-person variable revealed that there was a significant effect for Time, $F(1,56)=5.15, p = .03, \eta^2_p = .08$, but no significant effect of Group, $F(2,56) = .67, p = .52, \eta^2_p = .02$. In addition, the Time x Group interaction was not significant, $F(2,56)=.27, p=.76, \eta^2_p = .01$. Therefore, Rejection scores increased over time for all groups (see Figure 3.2).
To determine whether the prevention-promotion scale could distinguish among the three experimental groups as in Molden et al (2009), a separate one-way ANOVA was performed for Agitation and Dejection as the dependent variable and Group as the between-person variable. This analysis showed that neither Agitation, $F(2, 58) = 1.78, p = .18$, nor Dejection, $F(2, 58) = .39, p = .68$, scores differed significantly across Group. Therefore, the ER and IR groups could not be distinguished on the basis on the scores obtained from the prevention-motivation orientation scale.

3.2 Effects of Manipulations on Pain Outcomes

To examine the influence of experimental condition on each pain measure, a 2×3 analysis of variance (ANOVA) including one within-participants variable (time: before and after manipulation) and one between-participants variable (group: ER, IR, FH) was conducted on both
pain intensity and pain unpleasantness. For pain intensity, no main effects emerged for either time, $F(1,53)=.80, p = .38, \eta^2_p = .02$, or group, $F(2,53)=.99, p = .38, \eta^2_p = .04$. The time × group interaction, was also not significant, $F(2,53)=1.55, p = .22, \eta^2_p = .06$. For pain unpleasantness, no main effects emerged for either time, $F(1,53)=1.92, p = .17, \eta^2_p = .04$, or group, $F(2,53)=.42, p = .66, \eta^2_p = .02$. The time × group interaction, however, was significant, $F(2,53)=5.15, p = .01, \eta^2_p = .16$ (see Figure 3.3). Thus, the difference in pain unpleasantness (but not pain intensity) ratings depended on the group to which participants had been assigned.

![Figure 3.3](image)

**Figure 3.3**
Pain unpleasantness scores for each of the experimental groups at both pre- and post-manipulation pain tests.
Notes: IR = Implicit Rejection, ER = Explicit Rejection, FH = Financial Hardship

A simple effects analysis revealed a significant decrease in pain unpleasantness ratings from pre- to post-manipulation for those in the FH group, $t(53)=3.21, p = .003$, but not for either those in the ER group, $t(53)=2.92, p = .13$, or those in the IR group, $t(53)=.31, p = .80$. To compare group means after the experimental manipulation, an ANCOVA procedure was conducted on post-manipulation pain unpleasantness scores, controlling for pre-manipulation pain...
unpleasantness scores. A significant difference between the ER (Mean = 7.0, SD = 1.8), IR (Mean = 6.6, SD = 1.9), and FH (Mean = 5.4, SD = 1.7) groups was confirmed, F(2,55)=5.32, \(p = .01, \eta^2_p = .17\).

Pairwise contrasts indicate that the both the ER (Mean Diff=1.83, \(p=.003\)) and IR (Mean Diff=1.30, \(p=.02\)) rejection groups were significantly different from the FH group, but both rejection groups were not significantly different from each other, (Mean Diff=-.53, \(p=.34\)).

To ensure that pain unpleasantness ratings did not differ across groups before the manipulation, a one-way ANOVA was conducted on pre-manipulation pain unpleasantness scores. No significant differences were found between groups for pre-manipulation pain unpleasantness scores, F(2, 58) = .68, \(p = .51\), for ER (Mean = 6.4, SD = 1.8), IR (Mean = 6.7, SD = 1.9), and FH (Mean = 7.0, SD = 2.3).

### 3.3 Did VVIQ Scores and/or Vividness Ratings Moderate the Relationship Between Groups and Pain?

To assess whether the relationship between treatment group and pain depends on individual differences in participants’ imagination capacity as measured by the VVIQ scale, a hierarchical linear regression analysis was performed in which VVIQ \(\times\) Group interaction terms were entered in addition to Group. Adding the interaction terms did not significantly increase the percentage of variance accounted for by VVIQ scores in pain unpleasantness change scores, \(\Delta R^2 = .02\), \(P=.58\). Thus, VVIQ scores did not moderate the effect of Group on changes in pain unpleasantness from pre- to post-treatment.

To ascertain whether vividness ratings moderated the effects of the experimental treatments on pain reports, a hierarchical regression analysis was performed in which the difference in pain
from pre- to post-manipulation was regressed on terms representing Group, Vividness, and the Vividness × Group interaction. The addition of the interaction terms did not significantly increase the percentage of variance accounted for by vividness ratings in pain unpleasantness change scores, $\Delta R^2 = .04$, $P=.30$. Thus, vividness ratings did not influence the effect of Group on changes in pain unpleasantness from pre- to post-treatment.

### 3.4 Effects of the Manipulations on Affect Measures

To examine the effects of the manipulations on the five affect domains measured in this study (fear, hostility, sadness, fatigue, positive affect), a 2 (time) × 3 (group) analysis of variance (ANOVA) was conducted on each of the affect measures. As pre- and post-manipulation affect levels were measured using different scales (PANAS-X and POMS, respectively), subscale scores from each of these instruments were converted to z-scores prior to analyses in order to facilitate comparison. The results are presented in Table 3.1. A Time × Group interaction emerged only for sadness, $F(2,55) = 4.12$, $p = .02$, $\eta^2_p = .13$ (see Figure 3.4). Simple effects analysis revealed that only for the ER group was there a significant difference from pre- to post-manipulation sadness scores, $t(54) = 3.79$, $p < .001$.

---

12 Although there was no significant difference across groups on reports of dejection and agitation, the fact that sadness (which is related to dejection) increased over time for the ER but not the IR group suggests the ER manipulation may have been effective to some extent.
Figure 3.4.
Sadness ratings before and after the three experimental treatments.
Notes: IR = Implicit Rejection, ER = Explicit Rejection, FH = Financial Hardship

Table 3.2
Effects of Time and Group on affect measures.

<table>
<thead>
<tr>
<th>Affect domain</th>
<th>df</th>
<th>F</th>
<th>Sig</th>
<th>η²p</th>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>.07</td>
<td>.09</td>
</tr>
<tr>
<td>Time×Group</td>
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<td>1.09</td>
<td>.34</td>
<td>.04</td>
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<td>Hostility</td>
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<td></td>
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<tr>
<td>Time</td>
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<td>Group</td>
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<td>Sadness</td>
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<tr>
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<td>Group</td>
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<td>.33</td>
<td>.72</td>
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<tr>
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<td>.85</td>
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<tr>
<td>Group</td>
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<td>.07</td>
<td>.09</td>
</tr>
<tr>
<td>Time×Group</td>
<td>2</td>
<td>.72</td>
<td>.49</td>
<td>.03</td>
</tr>
<tr>
<td>Error df</td>
<td></td>
<td>55</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
To verify that sadness ratings did not differ across groups before the manipulation, a one-way ANOVA was conducted on pre-manipulation sadness scores. No significant differences were found between groups for pre-manipulation pain unpleasantness scores, $F(2, 58) = 1.49, p = .23$.

4 Discussion

The aim of this study was two-fold: 1) to investigate whether the hypoalgesic effect following the socially disconnecting experience of Study 1 would be replicated using a different method (imagination) and 2) whether a more explicitly disconnecting experience would induce a distinct effect on pain. Counter to expectation and to previous research (e.g., DeWall & Baumeister, 2006), neither of the two rejection groups (ER, IR) exhibited a significant change in pain ratings after the imagination task when compared to baseline. On the other hand, the FH group experienced a decrease in pain unpleasantness of about 1.25 points on an 11-pt scale. Given the relatively high correlation ($r = .64$) between post-manipulation pain intensity and pain unpleasantness scores, it seems odd that the effect of the FH task on unpleasantness did not also occur for intensity, raising the possibility that the effects observed for pain unpleasantness were spurious. In any case, the question arises as to why the hypoalgesic reaction observed in Study 1 was not replicated in this study.

One possibility is that while sufficient to induce feelings of rejection (as it did in this study and in experiments by Molden et al, 2009), the imagination task may have been ineffective in provoking the physiological sequelae that presumably leads to pain inhibition. One way of testing this possibility is to examine the relationship between how vividly participants perceived their imagined scenarios and changes in pain ratings from pre- to post-treatment. Assuming that
more intense vividness would lead to stronger psychophysiological effects, if higher vividness predicts stronger effects on pain ratings then imagination potency may be playing a role in the results. Regression analysis showed, however, that there was no relationship between vividness and pain ratings, therefore arguing against this possibility. People who felt that their imagined scenarios were highly vivid were no more or less sensitive to painful stimuli than those individuals who believed the vividness of their imagined scenario was poor.

Another possibility is that the imagination exercise provided the opportunity to engage coping and threat minimization strategies. For example, participants may have supplemented their imaginings with conditions that effectively enhanced their perceptions of control and escapability, which have been shown to be associated with diminished stress (Dickerson & Kemeny, 2004; Thompson, 1981). To investigate this possibility, a supplemental analysis was performed with the goal of coding participants’ narratives for perceived threat, shame and coping efforts. Unfortunately a reliable coding scheme did not emerge. A qualitative review of the rejection narratives revealed frequent evidence of threat minimization attempts. For example, “…probably will call my mom or my best friend to talk it out; after the conversation I'll try to shake it off; will try to distract myself with other things.”, “…I would think that the person is really stupid because they don't know what they're missing out on…”, “…We would be close together but I would feel hurt, and try and recover as fast as possible - probably by keeping my mind off it and trying to do other things…”. In addition to their potentially inhibitory effects on pain, such threat minimization strategies may have also diluted between group differences on the agitation and dejection measures, which has previously been shown to distinguish between explicit and implicit rejection (Molden et al, 2009). Financial troubles, by contrast, may not be so easily dismissed, chiefly because words alone, no matter how indicative of a resolve to assert
control and escape the situation, cannot make the problem go away or assure success. Out of 19 FH narratives, only two included some indication that they could effectively control and/or escape from their situation: “I feel dejected, but at the same time I have faith that things will turn out alright. I think that everything happens for a reason- especially the bad things. But for the moment, I feel disgusted with myself, and feel inferior to others”, “Hope and optimism are always with me. There might be times when I would feel down but never hopeless. I would rid myself of all unnecessary spending, cut as many expenses as possible, travel via bike and walk. I would try and keep busy” and “I would look for any part time jobs such as science tutor teaching high school students, waitress, cashier (sic) at Loblaw’s near my house, and server at sandwich shops, to pay off interest or debt. I would rather walk than take TTC to save transportation fees.”

Future studies employing the imagination paradigm to induce feelings of social exclusion should probe more explicitly for perceived threat, control and the use of coping efforts.

The attempts at minimizing threat in evidence in the narratives may have been prompted by participant instructions to “imagine” rather than to “recall” particular scenarios. The task of imagining a possible negative scenario offers the freedom to craft a narrative in whatever way participants deemed suitable and might have tapped into the natural human tendency toward optimism (Weinstein, 1980; Hoch, 1984; Sharot, 2011). Recalling a past episode of rejection would, by comparison, impose restrictions on this freedom, and therefore threat minimization might have been less frequent.

The FH group was intended as a comparison group – to induce negative affect without the element of social exclusion present in the two rejection groups. Yet, while neither rejection scenario prompted any change in pain sensitivity, imagining financial troubles induced a decrease in pain sensitivity as indicated by significantly lower pain unpleasantness ratings.
immediately after the imagination exercise when compared to baseline. This difference occurred despite the FH group reporting the same degree of exclusion as the rejection groups. As alluded to above in the discussion of the narratives, if not a spurious finding, one plausible explanation for this outcome is that the FH group experienced different types of, or more intense, affect and stress than either of the rejection groups. Financial troubles may carry potentially more grave and lingering consequences than a single episode of rejection, which can be “waved away” by words alone. Indeed, it can be argued to financial troubles may foretell of a future in which one experiences a series of likely rejections. Analyses of the affect ratings showed that none of the affect domains measured (positive affect, fear, fatigue, sadness, hostility), mediated the effect of group. Measures more targeted to factors that have been shown to moderate pain such as controllability, escapability, predictability, and apparent duration of the adverse conditions, as well as perceived threat might help to elucidate the reason for the possible hypoalgesic effect observed in the FH but not the rejection groups.

Although the FH condition was originally conceived of as a means to induce negative affect without a social element, it appears that a social element was indeed present. First, the measure of social exclusion assessed both before and after the manipulation showed no difference across groups, meaning that the FH group felt as rejected as those in the rejection groups. Second, a review of participants’ narratives revealed many references to the social consequences of their financial situation. Here are only a few excerpts: “I feel like I'm in a bubble; feel lonely”, “I feel like my heart is breaking and that I am alone and rejected and don’t know where to go”, “My grandfather and aunt would offer me money and I would accept it guiltily, knowing that it would take years to repay them”, “I feel disgusted with myself, and feel inferior to others”, “I wouldn't want to tell my parents cause I wouldn't want them to be disappointed and I would probably lie
to most people about the situation cause I would be too ashamed if they found out.” Thus, even imagining scenarios of financial hardship, which at first blush, has little to do with social exclusion, appears to have considerable social implications.

This connection between money and social connectedness has been demonstrated previously in the literature. For example, Zhou, Vohs, and Baumeister (2009) showed that interpersonal rejection (and physical pain) increased the desire for money, and that handling money reduced the distress resulting from exclusion (and physical pain). People may see money as a resource that can be tapped into to reduce distress, and boost self-sufficiency (Vohs, Meade, & Good, 2006) arising from both physical and social threats. Being without money, therefore, would mean that this potent resource would not be available, which may be perceived as highly threatening.

One of the limitations of this study is that the FH group apparently involved a greater social element than initially anticipated and therefore its role as a comparison group was compromised. Members of this group experienced a significant drop in pain unpleasantness after their imagination exercise but there is insufficient data to ascertain whether this decrease was due to the intensity of the threat (recalling the finding by Rhudy et al, 2008 that intense threats lead to pain inhibition), the potent social ramifications (revealed in several participants’ narratives), or the fact that financial troubles pose a more lingering, potentially more threatening scenario, which could not be as easily dismissed or managed as would be the case with an acute rejection episode. It is also possible that this effect was spurious. Future studies using the imagination paradigm should include comparison groups that carefully control for these possibilities.

The imagination paradigm employed in this study has some inherent weaknesses. For one thing, although care can be taken to specify exactly what participants should imagine, it is not possible
to control what participants actually conjure in their minds. There could be substantial differences among individuals in the scenarios they visualize; yet there would be no way to objectively ascertain these differences. Therefore, future research should employ treatments that are more reliable and explicit. There are other frequently used and more realistic social exclusion paradigms that may be used in future research. In one of these, (see e.g., Baumeister, DeWall, Ciarocco, & Twenge, 2005), volunteers take part in a get-acquainted task after which they rate with whom they would like to work individually at a subsequent task. Then they are randomly assigned to either receive a message that no one expressed interest in working with them (the rejection condition), or that everyone wanted to work with them. This paradigm could be adapted to enable different forms of rejection such as the explicit and implicit forms involved in the present study.

There are two key limitations inherent in Studies 1 and 2. First, participants were relatively healthy and pain-free. Their responses to social exclusion experiences may well be different from the way that people living with pain would respond. Second, although attempts were made to use exclusion methods that draw on experiences with which most people are familiar from everyday life, the social interactions in both studies (either real as in Study 1 or imagined as in Study 2) were nonetheless contrived. The purpose of Study 3 was to address these issues by investigating the relationship between daily social interactions and pain in a sample of chronic pain patients.
Chapter 4
Study #3

1 Introduction

In studies examining the effects of social disconnection on pain (DeWall & Baumeister, 2006; Eisenberger et al, 2006) otherwise healthy volunteers are subjected to social exclusion treatments and then to painful stimuli such as pressure or heat and their responses measured. In all cases, the pain stops as soon as the stimuli are withdrawn and total exposure to pain is on the order of minutes. But what happens when the pain persists for months or years? Might the effects of social connectedness experiences impact people living with chronic pain differently than those exposed to acute pain events?

The International Association for the Study of Pain (IASP) defines chronic pain as “... pain that persists past the normal time of healing... With non-malignant pain, three months is the most convenient point of division between acute and chronic pain, but for research purposes six months will often be preferred.” (Merskey & Bogduk, 1994). Chronic pain is a distinct phenomenon from acute pain and the distinctions that characterize chronic pain may bear upon the relationship between social experience and physical pain.

Chronic pain is known to be associated with several consequences that are absent or greatly minimized with acute pain: 1) chronic pain entails “secondary affect” such as depression, anger, and anxiety that are typically not at issue when pain is time limited. 2) brain imaging studies have shown that chronic pain is associated with neural systems that are distinct from those commonly observed in studies involving acute pain. 3) chronicity leads to neurophysiological
changes that alter how the brain responds to various stimuli. I will next briefly discuss each of these.

First, the persistent and often unrelenting nature of chronic pain brings with it a host of psychological and social consequences that are typically not at issue during periods of acute pain (Brown, 1990; Cornelissen, Rasker & Valkenburg, 1988). In many cases a diagnosis has not been ascertained, leaving the individual dealing with not only pain but also uncertainty. Even when the cause is known, many conditions prove recalcitrant to treatment, even with potent analgesics (Dworkin et al, 2007; Rowbotham et al, 2003).

Functional impairments often interfere with work, typically preventing individuals from enjoying a normal range of activities and often interfering with participating in, and enjoying activities. Thus, the unpleasantness of unrelenting pain, together with the uncertainty, diminished control, and interference with work and social activities typically provoke an assortment of emotional and cognitive responses such as depression, frustration, fear, isolation, worry about the future, and a diminished sense of self-efficacy, all of which are typically absent in most cases of acute pain.

Second, brain imaging studies have shown that a brain that has been experiencing pain for a long time pain is morphologically and functionally distinct from a brain not in pain. Long-term pain appears to change the structure and operation of the brain in a number of ways. For example, using MRI, Apkarian, Sosa, Sonty, et al (2004) observed significantly decreased global gray matter volume in chronic back pain patients compared to matched pain-free controls. Apkarian, Bushnell, Treede, et al (2005) compared the neural activation patterns observed in brain imaging studies that involved the experimental evocation of acute pain with those observed in patients
with painful clinical conditions. They found that chronic pain conditions more frequently involve the PFC (81% in chronic conditions vs. 55% in healthy volunteers), whereas acute pain more frequently involves S1, S2, thalamus, and ACC (82% in healthy volunteers, vs. 42% for those with chronic conditions). This shift in activity toward the PFC may reflect the finding that sensory processing plays an increasingly diminished role while emotional and cognitive factors become more centrally involved (Apkarian et al, 2005).

Third, chronicity leads to neurophysiological changes that alter how the brain responds to various stimuli. For example, while it is well established that acute episodes of stress can induce hypalgesia (Butler & Finn, 2009), there is evidence from studies using animal models that when stress has become chronic, the opposite, hyperalgesia tends to occur (da Silva Torres, et al 2003; Gamaro et al, 1998; Lovick et al, 2008; Imbe et al, 2006; Quintero et al, 2003; Robbins et al, 2007; Caceres & Burns, 1997). It has also been observed that chronically stressed rats require higher doses of morphine to achieve the same degree of pain inhibition (Puglisi-Allegra & Oliverio, 1983).

Taken together, there is sufficient reason to suspect that responses to the day-to-day social events of people living with persisting pain may well be entirely distinct from responses to contrived treatments in otherwise healthy individuals exposed to bouts of acute experimentally induced pain. The purpose of Study 3, then, was to investigate whether the relationship between experiences of social connectedness and pain uncovered in DeWall and Baumeister (2006) and in Study 1 generalize to the daily experiences of a sample of chronic pain patients. The aim is determine whether social connectedness felt in the context of real social interactions taking place in the everyday lives of people with chronic pain can impact physical pain.
To do so an experience sampling methodology was employed in which participants completed multiple diaries over a day across a 3-week period. Each diary asked participants about their pain and emotional state during both their most recent social and non-social experiences. Diary questions pertaining to social interactions also included how emotionally close they felt with the others, how much pleasure/satisfaction they derived from the interaction, and the number of people involved as well as emotional state and pain.

If experiences that leave people leaving socially disconnected in experimental settings are sufficiently threatening to provoke pain inhibition, then this effect should be observed in a chronic pain sample, perhaps to an even greater extent because the experiences take place out “in the real world” rather than within the atmosphere of a psychology experiment. Thus, I hypothesized that low levels of social connectedness during social interactions would predict lower levels of subsequent pain. The longitudinal nature of this study provided the opportunity to investigate not only the influence of social connectedness on pain but also the reverse, the effects of pain on social connectedness. I hypothesized that higher levels of physical pain would be associated with, and predict subsequently, lower levels on measures of social connectedness.

2 Methods

2.1 Participants

Participants were recruited via Internet-based chronic pain forums and discussion groups as well as from social networking sites such as Facebook. A standard recruitment notice, with a website URL and contact email address was distributed to forum/group moderators. Individuals who were older than 21 years of age, had chronic pain for at least 6 months, and had a typical sleep-wake cycle (i.e., awake during day, asleep at night) were deemed eligible to participate. Eligible
individuals were presented with an informed consent form. During the period from April 20, 2010 to November 30, 2010, 230 individuals enrolled in the study. Participants finished the study when they completed all psychological questionnaires and at least 2 (of 3) diary entries per day for a total of 21 days. Of the total number who enrolled, 132 began the diary phase (the principal phase) with 40 meeting the criteria for completion of the study (37 female). Seventy percent of the final sample was between ages 31 to 55 years, 18% were younger than 31 years, and 12% were older than 56 years. The majority (80%) had chronic pain for at least 3 years (see Table 4.1).

Table 4.1
Chronic pain sample demographics summary.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>37</td>
<td>93</td>
</tr>
<tr>
<td>Male</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 31 yrs</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>31 – 55 yrs</td>
<td>28</td>
<td>70</td>
</tr>
<tr>
<td>&gt; 56 yrs</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Pain Chronicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 yr</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>1-2 yrs</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>3-5 yrs</td>
<td>15</td>
<td>37</td>
</tr>
<tr>
<td>&gt; 5 yrs</td>
<td>17</td>
<td>43</td>
</tr>
</tbody>
</table>

2.2 Measures and Apparatus

2.2.1 Online diary measures

Participants were asked to make 3 diary entries per day on an interval schedule (once in the morning just before lunch; once in the afternoon, just before dinner; and once in the evening before going to sleep), over a period of 21 days. For each of their daily diaries, participants were asked to recall both their most recent social and non-social event and to answer a set of 14
questions about each (see Appendix B for the complete list of items used for each diary). Participants were informed that for the purposes of this study a “social interaction occurs when you are doing something nontrivial with other people. A conversation is probably the best example of an interaction, although interactions do not have to include continuous conversation.” After completing a set of questions pertaining to the most recent social interaction, participants were then asked to complete a similar set of questions pertaining to their most recent non-social activity, which was defined as, “Any activity not involving communications with another person.” Examples include reading the newspaper, watching television, eating alone, and showering.

Questions pertaining to the most recent social event assessed how participants felt at the time of that event. Questions about pain intensity, pain unpleasantness, pain intrusiveness, emotional closeness, and feelings of anger, being in control, anxious, optimistic, frustrated and optimistic, were rated on a scale from 1 (not at all) to 11 (very much). Questions pertaining to pleasure, stress, conflict, and connectedness were rated on a scale from 1 (not at all) to 7 (very much). They were also asked to indicate the type of their relationship (family, friend, neighbor, coworker, romantic, other) for each of the individuals involved in the social interaction. Questions pertaining to the most recent non-social event were identical except that items relating to interaction partners (whom and how close?) were omitted. In addition, 3 more general items were included. One asked participants to rate their overall sense of wellbeing during the period related to the diary (e.g., that morning); another asked about the degree to which pain meds were consumed in doses that were higher than, less than, or at the same level as usual (asked only in evening diaries); and another question asked about the number of hours slept in the previous
night and the quality of that sleep (asked only in the morning diaries). All items were rated on an 11-point scale from 1 (not at all) to 11 (very much).

Loneliness. The Revised UCLA Loneliness Scale, version 3 (UCLA-R; Russel, 1996; Russell, Peplau, & Cutrona, 1980). The UCLA-R is a 20-item questionnaire assessing perceived social isolation and satisfaction with connections. Each item is a statement such as “How often do you feel outgoing and friendly?” and “How often do you feel isolated from others?” Participants respond on a scale from 1 (never) to 4 (always). The UCLA-R is the most widely used measure of loneliness. Cronbach’s α ranged from .89 to .94.

Attachment. Attachment Style Questionnaire (ASQ; Feeney, Noller & Hanrahan, 1994). The ASQ is a 40-item instrument that measures the two attachment dimensions, anxious and avoidant attachment. Respondents provide answers on a 6-point scale from 1 (totally disagree) to 6 (totally agree). The scale measures anxious attachment \( (M = 3.03, SD = .64) \) with 13 items (e.g., “I often feel left out or alone”), Cronbach’s α = .81, and avoidant attachment \( (M = 3.35, SD = .60) \) is measured with 16 items (e.g., “I prefer to depend on myself rather than other people”), Cronbach’s α = .78.

Depression. Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977). The 20-item CES-D is one of the most commonly used self-report instruments to assess presence and degree of depressive symptoms. Its items probe mood, somatic complaints, interactions with others and motor functioning. Items include “I was bothered by things that usually don’t bother me”, “I did not feel like eating; my appetite was poor”, and “I felt that I was just as good as other people” and are answered on a 4 point scale from 1 (“Rarely or none of the time”) to 4 (“Most or all of the time”). It has been employed extensively in the literature and been shown to have good
psychometric properties and its 4 factor structure has been shown to be relatively robust (Eaton et al, 2004). Cronbach’s alpha was .91.

Social anxiety. The Brief Fear of Negative Evaluation Scale (BFNES; Leary, 1983) is a 12-item questionnaire based on a full version by Watson and Friend (1969). Items include, “I worry about what other people will think of me even when I know it doesn’t make any difference”, “I am unconcerned even if I know people are forming an unfavorable impression of me”, and “I am frequently afraid of other people noticing my shortcomings.” Respondents rate how characteristic each item is of them on a scale from 1 (not at all characteristic) to 5 (extremely characteristic). Cronbach’s alpha was .94.

2.3 Online Diary System

The online diary system (ODS) was a custom designed and developed web-based system that automated all aspects of running the diary study. Eligibility was ascertained, signed informed consent obtained, participants enrolled, and the details regarding participant progress tracked continuously without human intervention. The ODS was designed to make the process of making 3 regular diary entries per day for 21 days as quick and easy as possible.

2.4 Procedure

2.4.1 Step 1: Training video

Upon completion of the enrollment procedure and arriving at the homepage for the first time, participants were instructed to watch a 10-minute video “screencast” tutorial. The screencast explained everything participants needed to know in order to participate in the study and was required viewing.
2.4.2 Step 2: Questionnaires

After watching the video, participants were next asked to complete a set of 10 individual difference questionnaires: Not all the questionnaires were pertinent to the questions begin pursued in my thesis research. Therefore only the results from the demographics, UCLA-R, CES-D, BFNES, and ASQ will be included in this report. After all questionnaires had been completed, the Questionnaires section of the homepage disappeared and the morning, afternoon, and evening Daily Diary buttons appeared and were activated.13

2.4.3 Step 3: Diary entries

Throughout the 21-day diary phase of the study, participants were asked to complete 3 diaries per day on an interval type schedule (morning, afternoon, evening) for a total of 21 days, although 2 daily diaries were sufficient to count as a completed day14. At intervals of 7, 14 and 18 days (what I have referred to as “milestone” days), messages were automatically displayed to celebrate their achievement of the milestone and to encourage continued involvement. On the 18-day milestone, participants were reminded that they had only 3 days remaining.

2.4.4 Step 4: Debriefing

Upon completing the 21st day, a message appeared on the homepage indicating that the study had been completed and two links were provided. One link enabled the downloading of a debriefing form, which explained the study in detail. The second link asked participants to provide feedback

13 Though these questionnaires were included, none moderated any of the effects reported, and thus are not discussed further.
14 Previous testing revealed that it proved difficult for many people to make all 3 diaries. Requiring 3 daily diary entries proved too burdensome, leading to attrition. On the other hand, allowing only 1 per day, would have resulted in an insufficient sample sizes required to perform many types of important analyses. Therefore a day was counted as completed in which any 2 diaries were made.
(which all of them did). Finally, participants were thanked for their efforts and dedication and were promised that they would receive their personal reports within 4-6 weeks.

3 Results

A comparison of age and pain duration for participants who completed versus those who did not complete the study is presented in Table 4.2. Note that there is no difference between average age between completed and not completed groups.

<table>
<thead>
<tr>
<th></th>
<th>Completed (SD)</th>
<th>Not Completed (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>42.5 (11.1)</td>
<td>39.8 (10.5)</td>
</tr>
<tr>
<td>Pain Duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2 years</td>
<td>17.9 %</td>
<td>18.8 %</td>
</tr>
<tr>
<td>3-5 years</td>
<td>38.5</td>
<td>20.3</td>
</tr>
<tr>
<td>&gt; 5 years</td>
<td>43.6</td>
<td>60.9</td>
</tr>
</tbody>
</table>

The bulk of the people who did not complete the study had pain for at least 5 years (the longest period identified), whereas the bulk of people who did complete the study was distributed fairly evenly between those who had chronic pain for 3-5 years and those who had pain for at least 5 years. This result is not especially surprising – it may have simply been that participation was harder for those who have had pain for a longer period of time.

3.1 Data reduction

3.1.1 Psychosocial measures

Given the large number of items recorded in the daily diaries, an exploratory factor analysis (EFA) was performed to ascertain whether it would be possible to cluster items into a set of
components. To do so, a principal components analysis (PCA) was conducted on the 14 diary variables pertaining to psychological state with oblique rotation (oblimin). The KMO measure verified the sampling adequacy for the analysis, KMO = .83 (“great” according to Field, 2009). Bartlett’s test of sphericity $\chi^2 (91) = 13026.092$, $p < .001$, indicating that correlations between items were sufficiently large to justify PCA. According to Field (2009), average communality after extraction should be $> .7$, and indicates that Kaiser’s criterion is accurate when there are less than 30 variables (there are) and communalities after extraction greater than .7 (which it is: .73). Four components had eigenvalues over Kaiser’s criterion of 1 and together explained 73.3% of the variance.\(^{15}\) The 14 variables were combined into four factors by taking the mean scores across the items loading on each factor. The names given to the 4 components were: 1) Upset 2) Confidence, 3) Social Satisfaction, and 4) Non-Social Satisfaction. See Table 4.3 for items comprising each factor.

<table>
<thead>
<tr>
<th>Table 4.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diary items comprising each of the four factor psychosocial factors captured in diaries.</td>
</tr>
<tr>
<td>Social Satisfaction</td>
</tr>
<tr>
<td>Social-satisfaction</td>
</tr>
<tr>
<td>Social-connectedness</td>
</tr>
<tr>
<td>Social-stress (-)</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Notes: Items prefixed with “Social” refer to items pertaining to participants’ most recent social interaction. Items prefixed with “Nonsocial” refer to items pertaining to participants’ most recent nonsocial event. The (-) symbol denotes items that loaded negatively on the factor.

\(^{15}\) In a previous iteration, the wellbeing variable was included but it didn’t load clearly on any of the 4 components so it was removed and the factor analysis re-run.
In addition to these four factors, two other psychological variables were captured in the diaries: how emotionally close participants felt with the individuals with whom they were interacting\textsuperscript{16}, and overall wellbeing\textsuperscript{17}.

<table>
<thead>
<tr>
<th>Table 4.4</th>
<th>Correlation among four psychological factors, and emotional closeness and wellbeing.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Social Satisfaction</td>
</tr>
<tr>
<td>Social Satisfaction</td>
<td>1</td>
</tr>
<tr>
<td>Emot Closeness</td>
<td>1</td>
</tr>
<tr>
<td>Non-Social Satisfaction</td>
<td></td>
</tr>
<tr>
<td>Upset</td>
<td></td>
</tr>
<tr>
<td>Confidence</td>
<td></td>
</tr>
<tr>
<td>Wellbeing</td>
<td></td>
</tr>
</tbody>
</table>

Notes: **Correlation is significant at the 0.01 level (2-tailed).

3.1.2 Pain measures

For each diary, participants were asked to report on three aspects of their pain experience during their most recent social event (e.g., phone conversation): pain intensity, pain unpleasantness, and pain intrusiveness. Another set of three pain measures was captured pertaining to their most recent non-social event (e.g., watching TV). Correlations among the 3 social event pain variables ranged from .77 to .90. Because they were strongly related, the 3 social event pain variables were averaged to create a single pain-social variable. The 3 pain measures for the non-social event were similarly strongly related. Therefore, the 3 the non-social event pain variables were averaged to create a pain-nonsocial variable. To determine how strongly pain ratings pertaining

\textsuperscript{16}Participants were asked to specify how many individuals in the interaction fell into each of 7 different types of relationships (coworkers/colleagues, family, friends, neighbors, people never met before, romantic partner, other) and how emotionally close they felt with the individuals falling into each type. Thus there was a single emotional closeness rating provided for family members in the interaction, a single rating for all friends, and so on. An overall average emotional closeness score was computed by taking the mean of all closeness ratings.

\textsuperscript{17}Unlike most of the other diary questions, subjective wellbeing pertained to the entire diary period, not to a specific social or non-social event period within the diary period.
to social experiences were related to pain ratings pertaining to non-social experiences, the
correlation between pain-social and pain-nonsocial was examined. The correlation was high
(.88), indicating that pain perceived to occur during social interactions was strongly related to
pain perceived to occur in the context of non-social events within a given diary. Hence, they
were combined into a single, final pain variable, *pain*.

### 3.2 Pain Conditions

There were a large number of pain conditions experienced by participants in this sample (see
**Table 4.5**). The total number of pain conditions exceeds the sample size because several
individuals reported more than one pain condition. These data parallel findings from
epidemiological studies finding that back and neck pain, migraines and fibromyalgia are among
the most common pain conditions (Health, United States, 2006)\(^\text{18}\), and many individuals suffer
from more than one concomitant pain condition.

\(^{18}\) [http://www.cdc.gov/nchs/data/hus/hus06.pdf](http://www.cdc.gov/nchs/data/hus/hus06.pdf)
Table 4.5
Pain conditions mentioned by participants in this sample.

<table>
<thead>
<tr>
<th>Pain Condition</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back pain</td>
<td>9</td>
</tr>
<tr>
<td>Migraines</td>
<td>9</td>
</tr>
<tr>
<td>Fibromyalgia</td>
<td>6</td>
</tr>
<tr>
<td>Neck pain</td>
<td>5</td>
</tr>
<tr>
<td>Degenerative disc disease</td>
<td>4</td>
</tr>
<tr>
<td>Neuropathic pain</td>
<td>3</td>
</tr>
<tr>
<td>Joint pain</td>
<td>3</td>
</tr>
<tr>
<td>CRPS</td>
<td>3</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>2</td>
</tr>
<tr>
<td>Leg Pain</td>
<td>2</td>
</tr>
<tr>
<td>Multiple limb pain</td>
<td>2</td>
</tr>
<tr>
<td>Non-migraine headaches</td>
<td>2</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>2</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>1</td>
</tr>
<tr>
<td>Scoliosis</td>
<td>1</td>
</tr>
<tr>
<td>Pelvic pain</td>
<td>1</td>
</tr>
<tr>
<td>TMJ</td>
<td>1</td>
</tr>
<tr>
<td>Diverticulitus</td>
<td>1</td>
</tr>
<tr>
<td>Trigeminal Neuralgia</td>
<td>1</td>
</tr>
<tr>
<td>IBD/colitis</td>
<td>1</td>
</tr>
<tr>
<td>Bursitis</td>
<td>1</td>
</tr>
<tr>
<td>Radiculopathy</td>
<td>1</td>
</tr>
<tr>
<td>Carpal tunnel</td>
<td>1</td>
</tr>
<tr>
<td>Ankylosing spondylitis</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
</tr>
</tbody>
</table>

3.3 Analytical Strategy

In this study, each participant completed 2 or 3 diaries per day over a period of 21 days.

Individual diaries are nested within days (2-3 diaries per day), which are in turn nested within participants. Thus, individual observations are not independent. Multilevel Modeling\(^9\) (MLM) is a statistical methodology specifically designed to analyze hierarchical data. Two major types of

\(^9\) Reflecting the diverse theoretical backgrounds (Heck, Thomas, & Tabata, 2010), multilevel models are commonly known by a number of other names, including hierarchical linear models, random coefficient models, and mixed models, etc.
MLM analyses are appropriate here: concurrent and lagged. Questions pertaining to concurrent effects ask about the degree to which one or more variables predict levels of outcome variable within the same interval of time. For example, does emotional closeness predict pain ratings at the same time? Correlational analyses reveal whether particular psychosocial factors are related to pain but do not allow causal inferences to be drawn. To obtain a better sense of causal pathways, lagged analyses can be performed. Questions pertaining to lagged effects ask about the degree to which one or more variables at Time A (e.g., morning) predict levels of an outcome variable at some later point in time (Time B), controlling for levels of the outcome variable at Time A. For example, does pleasure one feels during a social interaction recorded in the morning diary predict pain ratings recorded in the evening diary, after controlling for morning pain ratings?

The analytic strategy advocated by Heck (2009) and others (e.g., Raudenbush & Bryk, 2002; Twisk, 2006), and followed here, was to begin by specifying and testing a basic model in which all parameters were fixed and then adding in random components (for the intercept and predictors) as appropriate. In this manner, the fit of each model could be compared to previous models by subtracting the log-likelihood (an index of model fit) of each model from the value of the previous one. Only those models that significantly improved fit were retained. In practice, unfortunately, the addition of a random component sometimes led to an inability to converge on a solution for parameter estimates. When this happened, the most comprehensive model that showed a significantly improved fit over the basic model constituted the final model tested and was reported.

There is little precedent to guide the correct choice of span of time between predictors and pain. If psychosocial factors influence pain or vice versa, it seems most likely that the influence would
operate within some brief period, because the wider the span of time, the greater the impact of intervening factors. For this reason, lagged analyses were performed using two time intervals: morning to evening and evening to subsequent morning. All predictors used in analyses were grand mean centered.

3.4 Concurrent Relationship Between Social Factors and Pain Ratings

3.4.1 Do social factors predict concurrent pain?

To examine the relative contribution of each of the social factors in predicting concurrent pain, a multilevel model was tested in which pain was regressed on social satisfaction, emotional closeness and number of people involved along with the other psychological factors (non-social satisfaction, upset, confidence, and wellbeing) in order to control for non-social measures. After accounting for the non-social measures, it was found that neither social satisfaction, \( b = .07, \text{s.e.} = .05, t(1317.20)=1.42, p=.16 \), nor emotional closeness, \( b = .02, \text{s.e.} = .01, t(1275.61)=1.45, p=.15 \), was related to concurrent pain (see Table 4.6).

<table>
<thead>
<tr>
<th>Predictor</th>
<th>b</th>
<th>s.e.</th>
<th>df</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>social satisfaction</td>
<td>.07</td>
<td>.05</td>
<td>1317.20</td>
<td>1.42</td>
<td>.16</td>
</tr>
<tr>
<td>emot closeness</td>
<td>.02</td>
<td>.01</td>
<td>1275.61</td>
<td>1.45</td>
<td>.15</td>
</tr>
<tr>
<td>non-social satisfaction</td>
<td>-.01</td>
<td>.04</td>
<td>1327.09</td>
<td>-.22</td>
<td>.82</td>
</tr>
<tr>
<td>wellbeing</td>
<td>-.26</td>
<td>.04</td>
<td>1362.34</td>
<td>-6.25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>upset</td>
<td>.46</td>
<td>.02</td>
<td>1383.62</td>
<td>19.64</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>confidence</td>
<td>-.16</td>
<td>.03</td>
<td>1376.31</td>
<td>-6.15</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
3.5 Longitudinal Relationship Between Social Factors and Pain Ratings

3.5.1 Do morning social factors predict evening pain levels?

To test whether morning social factors predict evening pain after controlling for morning pain levels, a multilevel modeling lagged analysis was performed in which evening pain was regressed on all morning psychological factors entered simultaneously.

Table 4.7
Parameter estimates for multilevel model with morning psychological factors as predictors, and evening pain as the outcome. Predictors were entered simultaneously, in a single analysis.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>b</th>
<th>s.e.</th>
<th>df</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain (morning)</td>
<td>.36</td>
<td>.07</td>
<td>235.08</td>
<td>4.81</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>social satisfaction</td>
<td>.16</td>
<td>.10</td>
<td>219.21</td>
<td>1.55</td>
<td>.12</td>
</tr>
<tr>
<td>emot closeness</td>
<td>-.03</td>
<td>.04</td>
<td>212.57</td>
<td>-.92</td>
<td>.40</td>
</tr>
<tr>
<td>non-social satisfaction</td>
<td>.03</td>
<td>.08</td>
<td>213.78</td>
<td>.38</td>
<td>.71</td>
</tr>
<tr>
<td>upset</td>
<td>-.04</td>
<td>.08</td>
<td>236.76</td>
<td>-.50</td>
<td>.62</td>
</tr>
<tr>
<td>confident</td>
<td>-.03</td>
<td>.07</td>
<td>236.77</td>
<td>-.50</td>
<td>.62</td>
</tr>
<tr>
<td>wellbeing</td>
<td>-.03</td>
<td>.07</td>
<td>227.07</td>
<td>-.46</td>
<td>.65</td>
</tr>
</tbody>
</table>

After accounting for all the variance attributable to the other psychological factors, neither morning reports of social satisfaction, b=.16, t(219.21) = 1.55, p = .12, nor morning reports of emotional closeness, b=.03, t(212.57) = -.92, p =.40, were found to be significant predictors of pain reported in evening diaries (see Table 4.7). In addition, none of the other psychological factors significantly predicted evening pain. Thus, none of the psychological factors measured in morning diaries were related to pain levels reported later in the day.

3.5.2 Does morning pain predict evening social factors?

To test whether morning pain predicts evening levels of social factors after controlling for morning levels, a multilevel modeling lagged analysis was performed in which each of the evening psychological factors was regressed on the corresponding morning psychological factor.
and morning pain. The results are presented in Table 4.8. Of all the psychological factors, morning pain was found to be a (marginally) significant negative predictor of only evening wellbeing, $b=-.11$, $t(41.81)=-1.85$, $p=.07$. Higher levels of morning pain predicted lower levels of evening wellbeing.

<table>
<thead>
<tr>
<th>Table 4.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter estimates for a multilevel model lagged analysis regressing each of the evening psychological factors on morning pain.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>b</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>Evening Social Satisfaction</strong></td>
</tr>
<tr>
<td>Morning social satisfaction</td>
</tr>
<tr>
<td>Morning pain</td>
</tr>
<tr>
<td><strong>Evening Emotional Closeness</strong></td>
</tr>
<tr>
<td>Morning emotional closeness</td>
</tr>
<tr>
<td>Morning pain</td>
</tr>
<tr>
<td><strong>Evening Non-Social Satisfaction</strong></td>
</tr>
<tr>
<td>Morning Non-social satisfaction</td>
</tr>
<tr>
<td>Morning pain</td>
</tr>
<tr>
<td><strong>Evening Upset</strong></td>
</tr>
<tr>
<td>Morning upset</td>
</tr>
<tr>
<td>Morning pain</td>
</tr>
<tr>
<td><strong>Evening Confidence</strong></td>
</tr>
<tr>
<td>Morning confidence</td>
</tr>
<tr>
<td>Morning pain</td>
</tr>
<tr>
<td><strong>Evening Wellbeing</strong></td>
</tr>
<tr>
<td>Morning wellbeing</td>
</tr>
<tr>
<td>Morning pain</td>
</tr>
</tbody>
</table>

3.5.3 Do evening social factors predict the subsequent morning’s pain levels?

To test whether evening psychological factors predict the subsequent morning’s pain ratings, a multilevel modeling lagged analysis was performed in which morning pain was regressed on all
of the previous evening’s psychological factors. All psychological factors were entered simultaneously in the analysis. The results are presented in Table 4.9. After accounting for all the variance attributable to the other psychological factors, reports of wellbeing in the evening diaries significantly, positively predicted the subsequent morning pain scores, $b=.16$, $t(252.14)=2.17$, $p=.03$. Thus, higher ratings of evening wellness are predictive of higher pain ratings in the morning. No other evening psychological factor predicted pain levels the next morning.

**Table 4.9**  
Parameter estimates for a multilevel model with evening psychological factors as predictors and morning pain measures as outcomes. Predictors were entered in simultaneously, in a single analysis.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>b</th>
<th>s.e.</th>
<th>df</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evening pain</td>
<td>.51</td>
<td>.07</td>
<td>209.71</td>
<td>7.74</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Social satisfaction</td>
<td>.09</td>
<td>.09</td>
<td>231.62</td>
<td>1.07</td>
<td>.29</td>
</tr>
<tr>
<td>Emotional closeness</td>
<td>-.03</td>
<td>.05</td>
<td>231.80</td>
<td>-.57</td>
<td>.57</td>
</tr>
<tr>
<td>Non-social satisfaction</td>
<td>-.07</td>
<td>.07</td>
<td>231.62</td>
<td>-.92</td>
<td>.36</td>
</tr>
<tr>
<td>Upset</td>
<td>.002</td>
<td>.07</td>
<td>229.76</td>
<td>.03</td>
<td>.97</td>
</tr>
<tr>
<td>Confidence</td>
<td>-.10</td>
<td>.07</td>
<td>211.78</td>
<td>-1.45</td>
<td>.15</td>
</tr>
<tr>
<td>Wellbeing</td>
<td>.16</td>
<td>.07</td>
<td>252.14</td>
<td>2.17</td>
<td>.03</td>
</tr>
</tbody>
</table>

**3.5.4 Does evening pain predict the subsequent morning’s social factors?**

To test whether evening pain predicts any of the subsequent morning’s psychological factors, a multilevel modeling lagged analysis was performed in which each of the morning psychological factors was regressed on evening pain ratings. The results are presented in Table 4.10.
Table 4.10
Parameter estimates for lagged multilevel model with evening pain as the predictor and morning psychological factors measures as outcomes.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>b</th>
<th>s.e.</th>
<th>df</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Social Satisfaction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evening social satisfaction</td>
<td>.08</td>
<td>.05</td>
<td>255.87</td>
<td>1.38</td>
<td>.17</td>
</tr>
<tr>
<td>Evening pain</td>
<td>-.01</td>
<td>.03</td>
<td>165.27</td>
<td>-.48</td>
<td>.63</td>
</tr>
<tr>
<td><strong>Morning Emotional Closeness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evening emotional closeness</td>
<td>.08</td>
<td>.07</td>
<td>254.42</td>
<td>1.05</td>
<td>.29</td>
</tr>
<tr>
<td>Evening pain</td>
<td>-.03</td>
<td>.09</td>
<td>173.51</td>
<td>-.32</td>
<td>.75</td>
</tr>
<tr>
<td><strong>Morning Non-Social Satisfaction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evening Non-social satisfaction</td>
<td>.19</td>
<td>.05</td>
<td>375.93</td>
<td>4.01</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Evening pain</td>
<td>.03</td>
<td>.03</td>
<td>140.24</td>
<td>1.14</td>
<td>.26</td>
</tr>
<tr>
<td><strong>Morning Upset</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evening upset</td>
<td>.39</td>
<td>.07</td>
<td>193.05</td>
<td>5.84</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Evening pain</td>
<td>.08</td>
<td>.07</td>
<td>183.84</td>
<td>1.20</td>
<td>.23</td>
</tr>
<tr>
<td><strong>Morning Confidence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evening confidence</td>
<td>.51</td>
<td>.05</td>
<td>186.28</td>
<td>9.70</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Evening pain</td>
<td>-.05</td>
<td>.05</td>
<td>164.45</td>
<td>-.93</td>
<td>.35</td>
</tr>
<tr>
<td><strong>Morning Wellbeing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evening wellbeing</td>
<td>.13</td>
<td>.05</td>
<td>379.90</td>
<td>2.60</td>
<td>.01</td>
</tr>
<tr>
<td>Evening pain</td>
<td>-.14</td>
<td>.05</td>
<td>337.00</td>
<td>-2.74</td>
<td>.01</td>
</tr>
</tbody>
</table>

Evening pain was not a significant predictor of any of the social factors the subsequent morning. Morning wellbeing was the only psychological factor that was significantly predicted by the previous evening’s pain levels, $b = -.14$, $t(337) = -2.74$, $p = .01$. Higher levels of evening pain predicted reports of lower wellbeing the following morning.

3.5.5 Do increases or decreases in social factor levels over the course of the day predict evening pain scores?

To examine whether changes in psychological state over the course of one day predict mean daily pain on the subsequent day, a multilevel modeling lagged analysis was performed in which mean daily pain was regressed on all of the variables representing change in psychological
factors on the prior day. Analyses were restricted to morning diaries. Fixed effects results are presented in Table 4.11. Only daily change in wellbeing, \( b = -0.08, t (746.74) = -2.59, p = .01 \), and daily change in upset, \( b = -0.28, t (750.13) = 9.16, p < .001 \), were found to be a significant predictor of evening pain levels.

### Table 4.11
Parameter estimates for multilevel model with change in psychological factors from morning to evening as predictors and evening pain ratings as the outcome variable. Predictors were entered in simultaneously, in a single analysis.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>( b )</th>
<th>s.e.</th>
<th>df</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ social satisfaction</td>
<td>-0.02</td>
<td>0.03</td>
<td>746.83</td>
<td>-0.67</td>
<td>.50</td>
</tr>
<tr>
<td>Δ emot closeness</td>
<td>0.001</td>
<td>0.01</td>
<td>746.74</td>
<td>0.10</td>
<td>.92</td>
</tr>
<tr>
<td>Δ non-social satisfaction</td>
<td>-0.03</td>
<td>0.03</td>
<td>745.92</td>
<td>-1.06</td>
<td>.29</td>
</tr>
<tr>
<td>Δ upset</td>
<td>0.28</td>
<td>0.03</td>
<td>750.13</td>
<td>9.16</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Δ confident</td>
<td>-0.05</td>
<td>0.03</td>
<td>747.06</td>
<td>1.63</td>
<td>.10</td>
</tr>
<tr>
<td>Δ wellbeing</td>
<td>-0.08</td>
<td>0.03</td>
<td>746.74</td>
<td>-2.59</td>
<td>.01</td>
</tr>
</tbody>
</table>

### 4 Discussion
The goal of this study was to ascertain whether results from earlier studies of experimentally manipulated social exclusion in samples of healthy individuals would generalize to cases of naturally occurring social events in the daily lives of people living with pain. Neither of the social-specific measures (social satisfaction and emotional closeness) was significantly related to concurrent pain levels. Furthermore, they neither predicted later pain, nor were they predicted by earlier pain. In short, pain bore little relationship with the two measures of social connectedness captured in this study, social satisfaction and emotional closeness.

Wellbeing was the psychological factor that was most closely associated with pain. Wellbeing had a relatively strong negative relationship with concurrent pain, higher levels of evening pain were associated with lower levels of wellbeing reported the next morning, and higher pain levels
in the morning (marginally) predicted lower wellbeing reported that evening. The consistent
negative influence of pain on wellbeing underscores the deleterious impact that pain can have on
the overall quality of life of people suffering from persistent pain. On the other hand, the effect
of wellbeing upon pain appears more complicated. While morning wellbeing did not predict
evening pain, an increase in wellbeing over the course of the day did predict lower pain levels
reported at evening diaries. Also, while evening wellbeing predicted the subsequent morning’s
pain, the relationship was positive, meaning that higher levels of wellbeing at the end of one day
were related to higher perceived pain the next morning. Taken together, these results suggest that
while high levels of pain appear to consistently take their toll on wellbeing, the enjoyment of
greater wellbeing does not necessarily mean that lower pain will follow. Indeed, the fact that
higher wellbeing toward the end of one day may only portend worsening pain the following day,
may contribute to a feeling of “being on a rollercoaster.”

One reason that a relationship between social connectedness and pain did not arise may have to
do with the particular questions used to assess social connectedness. In this study, four diary
questions were included to assess psychological state concomitant with social experience. These
were pleasure, stress, social connectedness, and emotional closeness felt by participants during
their most recent social interaction. Exploratory factor analyses found that the first three items
loaded significantly onto a single factor, termed social satisfaction, and the final item, emotional
closeness, separated into its own factor. On the face of it, these factors seemed to capture the
essential aspects of the social experience that were pertinent to the hypotheses being tested in
this study. It is possible that other variables may have better captured level of connectedness and
the emotional sequelae typically following exclusion. For example, one or two items might aim
more at capturing emotional/social pain-like feelings.
Perhaps an effect of social satisfaction on pain might arise only at times where feelings of social disconnection exceed at least a moderate level of intensity. In other words, the relationship between social connectedness and pain may be a nonlinear one (see Figure 4.1). Feelings of disconnection may need to rise to some threshold level before processes that impact physical pain are engaged. This possibility of a nonlinear relationship was tested in separate supplemental multilevel analyses using quadratic and cubic terms but neither achieved statistical significance.

Given the design of this study, however, in which social interactions were sampled at 3 set times throughout the day regardless of how connected they made participants feel, there might have been an insufficient number of observations of high levels of disconnection available to detect its relationship with pain. In fact, out of a total of 1539 valid observations, restricting cases to those in which social satisfaction ratings were among in the 66th percentile or higher left a total of only 113 valid observations. Indeed, it is possible that chronic pain patients may have already learned to avoid such situations, making them even less frequently observable. An event-contingent diary schedule (Wheeler & Reis, 1999; Bolger, Davis, & Rafaeli, 2003) may be more suitable given a non-linear relationship between connectedness and pain in chronic pain samples.20

Furthermore, following Rhudy et al (2008), it may be that at moderate social disconnection levels, hyperalgesic processes would lead to enhanced pain sensitivity, but when social disconnectedness becomes relatively severe, pain modulation processes would shift leading to hypoalgesic effects. It is possible that stress severity serves as an indicator of the imminence of a threat. A highly severe stressor signals that danger is imminent and must be dealt with

20 An event-contingent diary schedule is one in which diary entries are made upon the occurrence of some event, which has been clearly specified to participants prior to beginning. This schedule is distinct from the interval-contingent design in which participants report on their experiences at regular pre-set times (Wheeler & Reis, 1999; Bolger, Davis & Rafaeli, 2003).
successfully to survive; on the other hand, moderate stress signals the need to be vigilant to some looming threat. Pain inhibition is most adaptive in the event of an imminent threat – vigilance is not necessary as the threat has been identified – what is important is escaping/surviving the threat. Pain at this time might interfere with this goal. On the other hand, pain enhancement is most adaptive in the event of a looming potential threat – attention towards, rather than away from internal and external signals is likely to enhance survival.

Figure 4.1
Possible relationship between degree of felt social disconnectedness and the change in physical pain (on a numeric rating scale from 0 to 10). Following Rhudy et al (2008), it is predicted that pain will increase relative to baseline upon surpassing a moderate level (5 – 6) of social disconnectedness and then drop relative to baseline upon reaching high levels (7 – 8) of social disconnectedness.

Another reason for the failure to find any relationships between measures of social connectedness and pain may be due to insufficient power. This study had a sample size of 40 participants and the majority of the 21 days of diaries per participant consisted of only 2 (e.g., morning and afternoon, but not evening) diary entries. One reason cited by participants in their feedback for making only 2 diary entries per day was the inconvenience of logging into the
online diary website. There may not have been a sufficient number of observations to achieve the power necessary to detect effects existing in the data. One of the advantages of multilevel modeling is its ability to not only model fixed effects, but random effects as well, which means that the relationship between social variables and pain can be tested to see if they vary across participants and across days within participants. In order to do so, however, a sufficient number of observations are required and if these are not available, multilevel modeling algorithms will fail to converge on a solution. This was indeed a persistent problem in the analyses performed on these data. The recommended way to rectify this problem is to remove random effects from the models submitted for analysis (Raudenbush & Bryk, 2002), but doing so erases the advantage of modeling random effects. Thus, future studies should achieve higher power by recruiting a greater number of participants. Also, improved diary systems that require less and easier data entry and that employ portable smartphone devices that improve convenience should greatly improve participant retention and encourage more complete data sets.

To make this study more closely comparable to Studies 1 and 2 it would be necessary to track the occurrence of events in which a failure to obtain a desired connection (implicit disconnection as in Studies 1 and 2) and feelings of connection loss (explicit rejection as in Study 2). Doing so, however, would have called for an event-contingent design in which the occurrence of a tracked event triggers a diary entry pertaining to the event. The reason is that rejection events were anticipated to be relatively infrequent. An event contingent design would have enabled participants to record responses about the event at or very near the event’s occurrence. On the other hand, an interval design, in which diary entries take place on a fixed schedule, would have most often required that participants recall a rejection event that had occurred sometime earlier. The separation in time between event and diary entry would therefore likely introduce recall
biases (Bolger, Davis, & Rafaeli, 2003). To implement such a design successfully would have necessitated the portability of either paper diaries or mobile electronic devices, both of which carry practical and/or economic disadvantages. This study, therefore, employed an interval-contingent diary design in which diary entries were made at regular intervals (such as morning, afternoon, evening) every day and participants were queried about their most recent social experiences, which may or may not have entailed social exclusion. As a result, this study tracked responses to social experiences in general. A more focused investigation of the relationship between socially disconnecting experiences, pain, and the quality of life in people with chronic pain using mobile devices such as smartphones (e.g., iPhone) would provide valuable data.

To my knowledge, this study was the first longitudinal study to investigate the bidirectional relationship specifically between social connectedness and the experience of pain in people suffering from chronic pain. The primary body of work in this area has studied the responses of healthy individuals in a single session exposed to experimentally induced pain in highly controlled environments. As noted earlier, chronic pain is distinct from acute pain in many ways. For example, pain that persists indefinitely has numerous psychosocial consequences that are typically absent or less intense in those experiencing pain of limited duration. An advantage of the online diary methodology employed in this study is that it permitted capturing data on chronic pain sufferers in vivo, as they went about their daily lives, over a period of weeks. This approach, therefore, preserved the complexity of the person-environment dynamics.

There are numerous promising possibilities for extending the current research. A future system could, for example, provide a means by which participants could pre-configure details about their social and work relationships. Participants would list the names of their relationships, the nature of those relationships (close friend, acquaintance, work colleague, parent, child, etc.), and
how emotionally close they typically feel with these relationships. Then, when making a diary entry about a social interaction, participants would need only select the name of a relation from a menu and, by virtue of the additional data linked to the name, a great deal of knowledge could be derived. This would then make diary entries much quicker while greatly expanding the amount and types of data that can be captured. Other areas made possible by the advent of smart phones and other powerful yet inexpensive devices include the ability to capture physical and physiological data. For example, every iPhone and many iPods include built-in accelerometers, which can provide objective measures of activity levels. There are also devices that can be used with the iPhone that measure heart rate, blood pressure and heart rate. Future studies should take advantage of these ever improving technologies to substantially enhance our understanding of the relationship between social factors and pain in chronic pain populations.
Chapter 5
Study #4

1 Introduction

Consistent with the vast majority of research on the relation between social connectedness and physical health, Studies 1, 2 and 3 examined pain as an outcome variable. That is, they tested the effect of social experiences on the perception of pain. The longitudinal nature of Study 3, however, also offered the opportunity to test the effect of pain on social experience. The results showed that pain was not a longitudinal predictor of social connectedness. There are numerous reasons why pain may not have predicted subsequent social experience in Study 3. For example, by definition, people with chronic pain are seldom without pain. The constant presence of pain may have made it difficult to detect an effect. Given the critical importance of social connectedness in human life, a finding that pain biases social perception negatively would have consequences for quality of life and would point to an important target in pain management efforts. The purpose of this study, therefore, was to more fully investigate the possibility that pain may influence social perceptions.

How might pain bias social perception? An abundance of evidence has shown that both acute and chronic pain can impact a wide range of cognitive processes, especially attention (Eccleston, 1994; Eccleston & Crombez, 1999; Veldhuijzen et al, 2006). Owing to its biological salience, pain is known to hold considerable sway over attention (Seminowicz & Davis, 2007; Moriarty, McGuire, & Finn, 2011) and strongly orients the individual toward actions aimed at injury prevention and recovery promotion (Chapman, 1995; Wall, 1994). Pain may therefore enhance vigilance to stimuli in the environment indicative of threat.
Evidence for this possibility comes by way of research on the mood congruency effect (Bower, 1981; Forgas & Bower, 1987; Fiedler, 1990). Mood congruency refers to a match between one’s affective state and perception. For example, a happy person will tend to predict better weather for a picnic than a sad person because sunnier weather matches their positive mood (Mayer, Gaschke, Braverman, & Evans, 1992). Physical pain typically consists not only of an aversive sensory element but also an unpleasant affective-motivational component that may include negative feelings such as distress or fear (Price, 2000; Rainville et al, 1999). There is evidence that pain (or the affective elements that typically accompany pain) can lead to an attentional bias toward pain-related constructs (Pearce & Morley, 1989; Asmundson, Kuperos, & Norton, 1997; Keogh, Ellery, Hunt & Hannent, 2001), which would be a specific form of the mood congruency effect (Fiedler, 1990; Forgas & Bower, 1987). For example, using a modified Stroop task, Pearce and Morley (1989) found that chronic pain patients were more susceptible to interference when the stimuli were pain related than when the stimuli were neutral, whereas healthy controls showed no such bias.

In sum, there is ample evidence that pain (both acute and chronic) is capable of biasing social judgments so as to become aligned with the shifts in attentional focus, thoughts, emotions and behaviors that typically accompany pain. The purpose of Study 4 is to explicitly investigate the effects of pain on social perception. To do so, pain lasting about 30 minutes was induced experimentally in half of the participants using a topically applied cream preparation containing capsaicin, the active ingredient in chili peppers. An inert hypoallergenic cream (placebo) was applied to the remaining half. Subsequently, participants were shown a short (approx 3 min) video depicting either a pleasant or unpleasant structured social exchange between two young women (characters A and B). After watching the video, participants answered a series of
questions intended to assess their perceptions of the interaction and the persons depicted. The study thus employed a 2 x 2 factorial design with two independent variables: Pain Level (none, high) and Video Situation Type (negative, positive).

The goal of the videos was to enable a comparison between how an observer in pain would perceive someone on the receiving end (character A) of an unpleasant interaction with how an observer not in pain would perceive the same character in the same situation. Pursuant to this goal, the behavior of character B was designed to be very clearly negative (or positive), whereas the behavior of character A, which was scripted to be similar across negative and positive videos, was designed to be more ambiguous so as to facilitate wider interpretation possibilities. Ambiguous behavior has been shown to bring out psychological biases. For example, a study of married couples found that low self-esteem individuals tended to interpret a partner’s responses as evidence of a lack of support and validation only when the behavior was ambiguous (Murray et al, 2002). Thus, it is under conditions of ambiguous social cues, in which interpretation is left equivocal, that psychological factors are most likely to cast their influence.

As pain has been shown to impact cognitive performance, particularly attentional processes, a test of attentional performance was also administered. This made it possible to test whether cognitive ability or distraction might have mediated any differences between pain and no-pain groups on measures of social perceptions.

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21 The scenarios depicted in the negative and positive videos were similar to the negative and positive interactions encountered by participants in Study 1. Character B (the partner) behaved in a manner parallel to the confederate in Study 1.
Overall, I hypothesized that the presence of pain would “cast a pall” over the behavior of character A, making her appear less happy, less likable, and more emotionally injured to those in the pain group compared to participants administered a placebo.

2 Methods

2.1 Participants

One hundred sixty participants (all female; 97% aged 18 to 25) were recruited from the first year psychology participant pool at the University of Toronto. As in studies #1 and 2, only individuals reporting no medical conditions or medication use associated with altered pain sensitivity were included in the study. Stimulus materials needed to be sex matched. Hence, to eliminate the need for two sets of stimulus materials, eligibility was restricted to females.

2.2 Measures and Apparatus

2.2.1 Pain stimulus

In order to investigate the effect of acute pain on social perceptions, it was necessary to experimentally induce a pain experience that would persist at a relatively constant level for the duration of both a social experience itself (in this study, a video) plus an interval during which social judgments were recorded. To do so, topical capsaicin was employed as the pain model for this study. Depending on the concentration, capsaicin can produce a burning pain sensation as well as secondary thermal alldynia (pain that results from normally non-noxious heat stimuli, such as warm water or a heating pad) and hyperalgesia (augmented pain response) (Petersen & Rowbotham, 1999).

---

2 The use of capsaicin as a pain model for research has increased recently and it is now regarded as a safe, noninvasive method to induce moderate pain that persists for a longer interval than can be achieved with other common experimental pain induction methods (Arendt-Nielsen & Andersen, 2005).
A widely available over-the-counter capsaicin cream (Capzasin-HP, Chattem Inc, Chattanooga, TN) containing 0.075% capsaicin was used for this study. At this concentration level, the cream itself is, for most people, insufficient to induce pain beyond a mild to moderate burning sensation, but it does provoke thermal allodynia – the surface of the skin on which the capsaicin is applied becomes highly sensitive to heat such that a warm, ordinarily non-noxious, heat source will provoke moderate to severe pain. Therefore once peak allodynia was achieved (within 35 mins according to pilot tests), an air-activated heating pad (Grabber; Grand Rapids, MI) was placed on top of the allodynic skin area. A lightweight self-sticking gauze material was wrapped around the arm and pad securing the pad in place. Pilot testing ascertained that the pad caused the skin surface temperature to warm and remain at about 40 degrees C for at least 20 mins. Ordinarily this heat level is insufficient by itself to cause pain, but applied to thermal allodynic skin, the pain can be augmented to a range of 7-9 on an 11 point (0 to 10) numeric rating scale. An advantage of this technique is that the pain can be eliminated immediately upon removal of the heat pad should participants become distressed. Pilot testing showed that the thermal allodynia remains for about 4 to 6 hours. For the no-pain condition, a hypoallergenic unscented inert topical cream was used (GlaxalBase, WellSpring Pharmaceuticals, Oakville, Ontario).

2.2.2 Social encounter video

To ensure that the social situation being judged remained constant between participants, a video recording was prepared depicting an interaction between two young women (age early 20s) who had apparently just met each other.

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23 Air-activated hand warmers are usually small lightweight pouches that become activated when air enters the pouch, causing iron in the pouch to oxidize, creating heat. They typically also contain other non-toxic ingredients including salt (as a catalyst), vermiculite (an insulator to trap the heat), and activated carbon (to distribute the heat evenly).

24 The probe of an electronic cooking thermometer (Model 1478, Taylor USA; Oak Brook, IL) was carefully slid between the pad and skin and held there for 20 minutes to confirm that the skin surface temperature remained at 40 degrees C.
The two dyad members engaged in a structured task called the Relationship Closeness Induction Task (RCIT; Sedikides, Campbell, Reeder, & Elliot, 1999), which consists of a series of increasingly personal questions. This was the same task used in Study 1. The two women in the video were in fact actors and were instructed to behave in particular ways. Two versions of the video were made: negative and positive. For both versions, one woman (character A) was alert and actively engaged in the task. To encourage immersion in the situation, participants were instructed to imagine that they were in the place of this character. In the negative version, the partner (character B) behaved in a standoffish manner, showing low interest in the task or in her partner, using clipped responses and making eye contact infrequently. The aim was to create a scenario in which character A was exposed to an implicitly socially disconnecting experience, much as participants experienced with the confederate in Study 1. In the positive version, the partner was actively engaged in the task, behaving cooperatively, showing interest, warmth, and making lots of eye contact.

2.2.3 Measures


Sensation. Sensation Rating Scale (SRS). The SRS is a brief questionnaire with 4 items, each assessing a different physical sensation: tingling, warmth, coolness, and pain. Each item asks the degree to which the individual is currently feeling the sensation on an 11 point scale from 0 (Not at all) to 10 (Very much).

Social judgments. The Social Perception Questionnaire (SPQ). Social perceptions were assessed using a questionnaire consisting of items designed to evaluate judgments of both members of the
video dyad. The instrument was divided into 6 sections. The first two sections each presented a list of personal characteristics such as “intelligent”, “shy”, and “friendly”, and asked participants to rate both characters A and B on 7-point scales with opposing terms as anchors (e.g., “unintelligent/intelligent”, “shy/outgoing”, “unfriendly/friendly”). The third section presented a list of emotion terms, such as “irritated”, “engaged”, and “tense” and asked participants to rate the degree to which they perceived that character A (whose behavior did not differ across the negative and positive interaction conditions) was feeling each of the emotions, from 1 (not at all) to 7 (very much). The fourth section asked participants to imagine that they were called upon to work with character B (the one whose behavior differed across video conditions) and then to predict the degree to which they would agree with a set of statements on a 7-point scale, including “click with the partner”, “want to get to know the partner”, and “feel close to the partner”. This scale was identical to the one used to assess connectedness in Study 1. The fifth section was the same as the fourth except participants were asked to respond from the perspective of character B being asked about character A. The final section asked a set of manipulation check questions such as “To what degree do you think character B liked/was interested in character A?” and a few additional questions to test that participants carefully watched the video, such as “how many times did character A interrupt character B?”, and “There were papers on the wall behind the characters in the video, what was printed on these papers?”


26 Complete list: irritated, engaged, nervous, hurt, annoyed, delighted, depressed, injured, dejected, cheerful, tense, sad, pained, anxious, happy, pleased, angry, down, mad, interested, alert, uneasy, wounded.
2.2.4 Cognitive task

The trail-making test (TST; Reitan, 1958) was administered prior to the video. The task is to connect the dots in the correct sequence. There are two versions. In the “A” test the dots are labeled with numbers (1, 2, 3, etc.) but in the “B” test, the dots are labeled alternately with numbers and letters (1, A, 2, B, etc.). The goal is to finish connecting all the dots as quickly as possible. The test has been found to be related to attentional ability. Both versions of the TST (A and B) were administered on paper and participant performance timed by the experimenter. Time to completion for each of the forms was recorded.

2.3 Procedure

The overall procedure is visualized in Figure 5.1, below.
2.3.1 Step 1: Participant prep, random assignment and informed consent

Once in the experimental setting, the experimenter introduced herself, asked participants to be seated, and read aloud the following information about the study:

“The purpose of the study is to investigate the potential effects of different kinds of physical sensations on cognitive processing. To produce the sensations, a randomly chosen cream will be applied to the skin of the forearm. The cream will produce one of several different sensations: cooling, warming, pain, or tingle. After application of the cream, two cognitive tests will be administered. One will be a paper and pencil test and the other entails watching a video and answering some questions about it. The cream is completely safe and its effects should wear off within a few hours.”

The experimenter then asked participants to carefully read the informed consent document and left the room for 2-4 mins to allow participants to do so.

2.3.2 Step 2: Application of cream

An area 10 cm long by 5 cm wide about 5 cm from the base of the thumb was marked off on the medial aspect of participants’ forearms using a washable marker. Both the capsaicin and placebo creams were applied over this area using even gentle strokes, taking care to distribute the cream evenly across the entire skin area. A thin self-sticking gauze material was then lightly wrapped around the forearm area containing the cream. This was done in order to prevent the cream from accidentally wiping off. The gauze also prevented touching the capsaicin cream, which would prove highly irritating if it got in participants’ eyes.
2.3.3 Step 3: Measures
Immediately following application of the cream, participants were asked to use the computer to complete the PANAS-X, plus a number of other measures not reported in this report. The experimenter then left the room and began timing the participant.

2.3.4 Step 4: Rate physical sensations
Pilot testing revealed that completion of the questionnaires took between 10-15 mins. Thus, after 10 mins had elapsed, the experimenter returned to the room to see if the participant was finished. If so, the participant was asked to wait 5 mins. If not, the experimenter left to allow the participant to continue and returned 5 mins later. This procedure was implemented to ensure that all participants would provide their first (baseline) SRS ratings (SRS-1) at no more than 15 mins after application of the cream.

2.3.5 Step 5: Perform diversion tasks
Pilot testing revealed that the capsaicin cream took about 35 mins to peak in effect27. As it was found that the preceding psychological questionnaires could be completed in less than 15 mins, two “diversion” tasks were therefore administered to provide time for the capsaicin to take effect: one in which they were asked to answer some questions about a short essay (taken from a Graduate Record Exam test) and the other was the Remote Associates Test (Mednick, 1962).

2.3.6 Step 6: Rate physical sensations (rating #2)
The second SRS (SRS-2) was administered.

27 The point at which the application of the heat pad reliably produced pain rating of 7 or higher on an 11-point numeric rating scale.
2.3.7 Step 7: Application of the heat pad

Participants were next told the following:

“The cream that was applied to your arm contains an ingredient that needs to be "promoted." Different people react to a greater or lesser extent to this ingredient. Promotion enables this individual variation to be minimized by promoting conditions in which most people react similarly. To do so, a warm pad will be applied and secured to the creamed region of your forearm.”

The heat pad was positioned over the site of the cream and then lightly wrapped in gauze to secure the pad in place.

2.3.8 Step 8: Rate physical sensations (rating #3)

The third SRS (SRS-3) was administered.

2.3.9 Step 9: Cognitive task

The trail-making task was administered.

2.3.10 Step 10: Rate physical sensations (rating #4)

The fourth SRS (SRS-4) was administered.

2.3.11 Step 11: Watch video

Upon completion of the SRS, participants were told that they would now be presented a short video depicting a social interaction between two individuals. They were instructed as follows:

“Imagine yourself as the main character of the video and attempt to experience the situation in the video as if it were really happening to you. Try to immerse
After clicking the “Ready” button, the video was presented.

2.3.12 Step 12: Provide social judgments
Following the video, participants completed the SPQ in order to assess various aspects of their social perceptions.

2.3.13 Step 13: Rate physical sensations
Participants completed the 5th and final SRS.

2.3.14 Step 14: Debriefing
Upon completion of the pain trials, participants received a funnel debriefing to probe for suspicions regarding the cover story and treatments.

3 Results
3.1 Manipulation Check
Three questions arise in assessing whether the pain manipulation worked as required: 1) Was pain present during questionnaire completion interval, 2) Did placement of the heat pad result in significant increase in pain for those in the capsaicin group, and 3) Did pain remain at a constant level from the time the heat pad was applied until the end of the experiment?

To verify that pain remained at or below moderate levels while completing the questionnaires, a one-way ANOVA was performed using the SRS pain ratings administered immediately after the questionnaires had been completed (SRS-1) as the dependent variable and pain group (capsaicin...
vs. placebo) as the between-subjects factor. Pain scores in the pain condition were significantly higher (mean 6.43) than in the placebo (mean 1.69) condition, $F(1,154)=102.96$, $p<.001$, $\eta^2_p = .40$. A frequency analysis revealed that 56 out of a total of 85 in the capsaicin condition (66%) rated pain at 6 or higher. Thus, more than two-thirds of participants in the capsaicin group reported pain levels in excess of what would be considered mild-to-moderate, making it questionable that pain remained at or below moderate levels while in the process of completing questionnaires.

To verify that the application of the heat pad led to a significant increase in reported pain levels for the capsaicin group but not the placebo group, a repeated-measures ANOVA was performed using pain ratings immediately before (SRS-2) and immediately after (SRS-3) application of the heat pad as the within-subjects measure and pain condition (capsaicin vs. placebo) as the between-groups factor. A significant main effect for time was found, $F(1,150)=7.41$, $p = .01$. This main effect was qualified by a significant time $\times$ pain condition interaction, $F(1,150)=30.08$, $p < .001$. Simple effects analysis revealed that for the pain group, there was a significant increase in pain ratings of 1.14 points ($SE=.19$, $p < .001$) from 6.75 to 7.89, whereas for the placebo group, there was a marginally significant decrease of .38 points ($SE=.20$, $p=.06$) from 1.70 to 1.32. Thus, the heat pad induced a significant increase in pain levels only for those in the capsaicin group.

To verify that pain remained at a constant level after placement of the heat pad, a repeated-measures ANOVA was conducted with pain ratings assessed immediately after application of the heat pad (SRS-3), immediately before watching the video (SRS-4), and immediately after completion of the SPS (SRS-5) entered as the within-subjects variable and pain condition as the between-subjects factor. No main effect for time occurred, $F(2,84)=.20$, $p = .82$, $\eta^2_p = .01$, but a
marginally significant time x pain-condition interaction did emerge, $F(2,84)=2.94$, $p=.06$, $\eta_p^2 = .07$. A simple effects analysis revealed that for the capsaicin group, mean pain levels lessened significantly by .74 points from SRS-3 to SRS-5 (SE=.35, $p=.04$) and by .59 points from SRS-4 to SRS-5 (SE=.24, $p=.02$). There was no significant change in pain ratings from SRS-3 to SRS-4 (mean diff=.15, SE=.24, $p=.53$). In contrast, there were no changes across the 3 pain ratings time points for participants in the placebo group. Thus, capsaicin-induced pain did subside somewhat from the point at which the heat pad was applied to the point at which social perception ratings were provided.

### 3.2 Data Reduction

To reduce the complexity of the outcome measures, a set of exploratory factor analyses was performed. Please see Table 5.1 for the list of factors and their component items. A principal component analysis (PCA) was conducted on the 18-items pertaining to perceived qualities of character B with oblique rotation (oblimin). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .93 (“superb” according to Field, 2009). Bartlett’s test of sphericity $\chi^2 (28) = 1073.23$, $p <.001$, indicated that correlations between items were sufficiently large for PCA. Only one component had an eigenvalue over Kaiser’s criterion of 1 and explained 72% of the variance. The variables were combined into a single factor by taking the mean scores across the items. Its name was based on the item that loaded most strongly on the component: **B-friendly**. Next, a PCA was conducted on the 14-items pertaining to perceived qualities of character A with oblique rotation (oblimin). The KMO measure verified the sampling adequacy for the analysis, KMO = .94 (“superb” according to Field, 2009). Bartlett’s test of sphericity $\chi^2 (91) = 1812.25$, $p <.001$, indicated that correlations between items were sufficiently
large for PCA. Two components had eigenvalues over Kaiser’s criterion of 1 and together explained 72% of the variance. Components 1 and 2 were named **A-kind**, and **A-bold**.

| Table 5.1 |
| Factors and their component items. |
| **Factor** |
| **B-friendly** | **A-kind** | **A-bold** | **A-injured** | **A-pleased** | **A-tense** | **A-irritated** | **A-disengaged** | **A-cnctd & BA-cnctd** |
| friendly | kind | bold | injured | pleased | tense | irritated | engaged (-) | clicked |
| polite | likable | shy | wounded | delighted | anxious | annoyed | interested (-) | close |
| coop’tive | good | en’getic | dejected | happy | uneasy | angry | alert (-) | friends |
| energetic | pleasant | | depressed | cheerful | nervous | sad | mad | know |
| likable | helpful | | | | | | | like |
| helpful | coop’tive | | | | | | | similar |
| good | polite | | | | | | | understand |
| shy | warm | | | | | | | |

Notes: "A-" and "B-" refer to ratings of video characters A and B, respectively. "BA-" refers to participant judgments regarding how video character B would feel about video character A. The "(−)" refers to variables that loaded negatively on the factor.

The 23 emotion adjective ratings were subjected to PCA with oblique (oblimin) rotation. The KMO measure verified the sampling adequacy for the analysis, KMO = .86 ("great" according to Field, 2009). Bartlett’s test of sphericity $\chi^2(253) = 1856.13$, $p < .001$, indicated that correlations between items were sufficiently large for PCA. Five components had eigenvalues over Kaiser’s criterion of 1 and together explained 67.7% of the variance. Components 1 through 5 were named **A-injured**, **A-pleased**, **A-tense**, **A-irritated**, and **A-disengaged**. The 7 items of connectedness scale assessing the participant’s predicted level of connectedness to character B was subjected to PCA, with oblique (oblimin) rotation. The KMO measure verified the sampling adequacy for the analysis, KMO = .93 ("superb" according to Field, 2009). Bartlett’s test of sphericity $\chi^2(21) = 1131.00$, $p < .001$, indicated that correlations between items were sufficiently large for PCA. A single component had an eigenvalue over Kaiser’s criterion of 1, which
explained 81.2% of the variance. Next, the 7 items of the connectedness scale assessing perceived level of connectedness felt by character B toward character A were subjected to PCA. A single component had an eigenvalue over Kaiser’s criterion of 1, which explained 86.2% of the variance.

In sum, the four factor analyses performed above reduced the total number of variables from 76 variables to 10 factors, each reflecting a distinct aspect of the perception of the social situation depicted in the video: B-friendly, A-friendly, A-bold, A-injured, A-pleased, A-tense, A-irritated, A-disengaged, A-connected, and BA-connected (see Table 5.1).

### 3.3 Was There a Relationship Between Group and Social Judgments?

To examine the influence of the Pain and Video conditions on each of the social perception dependent measures, a multivariate analysis of variance (MANOVA) was performed, with all social judgment measures entered as dependent variables and the Pain and Video conditions entered as fixed factors. Multivariate tests showed a significant main effect for Video version, $F(10, 123) = 31.85, p < .001, \eta^2_p = .72$, but no main effect of Pain group, $F(10, 123) = .90, p = .54, \eta^2_p = .07$, nor a Pain × Group interaction, $F(10, 123) = 1.50, p = .15, \eta^2_p = .11$ (see Figure 5.2). Thus, ratings were highly influenced by Video condition but not by the presence or absence of pain.
Figure 5.2
Social judgment ratings across the pain and no-pain groups by participants watching the negative video.
Notes: All judgment variables, except a-cnct and ba-cnct, measured on an 8-point scale from 1 (not at all) to 7 (very much); a-cnct and ba-cnct measured on a 10-point scale from 1 (not at all) to 9 (very much). * p < .01 ‡ p = .06. Error bars represent S.E. of the mean.

Although univariate tests of the Pain independent variable must be treated with caution given the lack of significant multivariate effects, exploratory analyses were conducted. Univariate tests showed a significant main effect of pain group on ratings of how disengaged character A appeared to be, F(1, 132) = 7.30, p = .008, η²_p = .05. Participants in the capsaicin pain group rated perceived character A as being less disengaged (i.e., more engaged) compared to those in the no-pain group. A marginally significant main effect of pain group on ratings of how pleased character A appeared, F(1, 132) = 3.49, p = .06, η²_p = .03, also emerged. Thus, there was a trend toward those in pain being less pleased compared to participants not in pain. Univariate tests of interaction effects revealed a marginally significant Pain × Group interaction on judgments of how pleased character A appeared to be, F(1, 132) = 3.42, p = .07, η²_p = .03 (see Figure 5.3).
A simple effects analysis confirmed that for those exposed to the negative video, the presence of pain prompted significantly higher ratings on the perception of how pleased character A appeared to be, compared to those without pain, $t(132) = 8.93, p = .01$. For participants exposed the positive video, the presence or absence of pain made no difference to pleased ratings, $t(132) = 0, p = .99$. No other significant univariate interaction effects emerged. Thus, across both video conditions, participants in the capsaicin pain group rated character A as less disengaged, whereas only for those in the negative (but not the positive) video condition, participants in the capsaicin pain group showed a trend toward judging character A as being less pleased than those in the placebo group.

![Figure 5.3](image)

**Figure 5.3**
Pain x Group interaction on how pleased character A was judged to be. $P = .07$, $\eta^2_p = .03$.

Notes: A-Pleased refers to participants' judgment of how pleased character A appeared in the video.

Univariate tests of the video condition revealed that participants in the negative video group rated character A as significantly more friendly, $F(1, 132) = 35.78, p < .001$, $\eta^2_p = .21$ and bold,
F(1, 132) = 31.08, p < .001, $\eta^2_p = .19$ than participants in the positive video group. In addition, the negative video group rated character A as significantly more injured, F(1, 132) = 4.87, p < .03, $\eta^2_p = .04$, significantly more disengaged, F(1, 132) = 4.73, p < .03, $\eta^2_p = .04$, marginally more irritated, F(1, 132) = 3.54, p = .06, $\eta^2_p = .03$, and predicted that they would feel significantly more connected with character A, F(1, 132) = 4.76, p < .03, $\eta^2_p = .04$, than the positive video group. Thus, the video in which character B acted negatively prompted participants to perceive character A more favorably than the positive video.

3.4 Was There a Difference Between Groups on Cognitive Performance?

To examine whether the presence of pain influenced attentional processes, a linear regression analysis was performed regressing performance scores on both the Trail-Making Test forms A and B on pain group. Pain was not a significant predictor of either Trail A performance, B = -.58, p = .67, or Trail B performance, B = 1.28, p = .64. Thus, the presence of capsaicin-induced pain had no effect on performance relative to those receiving the placebo substance.

4 Discussion

The purpose of this experiment was to test the hypothesis that, when compared to observers who are pain free, observers in pain will render harsher judgments of individuals engaged in a social interaction. Though multivariate analyses showed that participants watching the negative video under capsaicin-induced pain did not rate either video character any differently than participants who were not in pain, univariate tests suggested a possible effect of pain on one social perception variable. Across both video groups, participants in pain judged character A as being significantly more engaged than those given a placebo.
One possibility for the failure of pain to exert the expected effect on social judgments is that pain was insufficiently intense to provoke the cognitive biases observed in people with pain. This, however, is not likely the case as mean pain scores in the capsaicin pain group after placement of the heat pad reached a level (M=7.9) typically considered in the severe range. By comparison mean pain levels for the placebo group were considerably lower (M=1.3). A related possibility is that the capsaicin-induced pain diminished from the point at which the heat pad was first applied to the point in time at which social judgments were rendered. If so, participants may have felt a sense of relief that countered any negative effects of the pain. On the other hand, the tasks in which participants engaged (watching a video and responding to questions about the video) may have served as a distraction, thereby lowering pain and its potential effects. Pain ratings did in fact decline during this period but the magnitude of this change was small (.7 points) (Turk & Melzack, 2001). Although it is possible that insufficiently constant pain levels may have interfered with the influence of pain on social judgments, it seems unlikely given the small decrease. Thus, it appears that the pain manipulation successfully induced a moderately high level of pain that persisted largely unchanged for the duration of the experiment.

Another possibility for the lack of a pain effect has to do with the nature of the social stimuli used in this study. Firstly, for economical reasons and to ensure the consistency of treatments across participants, this study employed videotaped scenarios. Future studies should test different methods of depicting social situations. Perhaps the most ecologically valid method would entail a live interaction with a confederate who is instructed to behave in a specific manner. In this way, participants respond not to an empathic recreation of what it would be like to be in another’s place but instead to their own experience. Such a manipulation has the potential to be more powerful (i.e., provoking stronger pain effects) than the one employed in the current study.
Secondly, the objective in depicting an interaction between two characters was to use a situation that would seem relatively commonplace and therefore as ecologically valid as a video can be made to be. Unfortunately, social interactions have dynamics that may have added unnecessarily to the complexity of the scenarios. First, while the aim was for character A’s behavior to be ambiguous, she may not have come across that way. Regardless of whether her partner acted negatively or positively, character A consistently portrayed warm courteous behavior and showed interest in the task and her partner. Thus, although more ambiguous than character B, the behavior of character A may have been insufficiently so to prompt the emergence of pain effects on judgment. Second, the ongoing social interaction depicted in the video may have prompted participants to view the behavior of character A in the context of character B’s behavior. Character A may have been perceived as more positive in the negative video than in the positive video perhaps as a result of her maintaining friendliness in the face of an uncooperative partner. This possibility was borne out by the data showing that character A appeared significantly more friendly, bold, and engaged (though also more injured and irritated) when juxtaposed against the negative partner than she did when juxtaposed against the positive partner. One strategy might be to use a simpler exchange than the ongoing interaction depicted in this study. For example, a student may be seen asking a fellow student for help on an assignment, who insists she cannot and provides a reason (e.g., she has to look after her mother who is sick). This scenario entails only a single response A, rather than an extended exchange, which would make the response the focus and thereby less susceptible to the complex dynamics that emerge through extended interactions.

Univariate analyses showed that across both negative and positive video groups participants in pain rated character A as being less disengaged (i.e., more engaged) than their pain-free
counterparts. Furthermore, a trend emerged such that for those who watched the negative (but not the positive) video, the presence of pain also prompted participants to rate character A as less pleased compared to when pain was absent. It is reasonable to suppose these are spurious effects. If not, it is curious that participants in the negative interaction condition would simultaneously see character A as being both less pleased and also more engaged. It is possible that, in the context of a disinterested partner, the presence of pain led participants to perceive character A as making a greater effort to cope, even as they also recognized her as being less pleased. Perhaps the efforts to cope with one’s own pain induced a heightened sensitivity in participants for evidence of efforts to cope within others.

Finally, this study recruited only female participants. Given widely reported sex differences in sensitivity to pain, it is possible that the results reported herein may not generalize to males. Future studies should endeavor to include both sexes.
Chapter 6
General Discussion

1 Review of Findings

The aim of this program of research was to extend what is known about the relationship between social connectedness and the perception of physical pain. Using a live experience with a confederate that was designed to induce feelings of disconnection, Study 1 revealed diminished pain sensitivity after the interaction relative to baseline. No change in pain was observed for participants exposed to a positive interaction with the confederate. This finding is consistent with previous research on the effect of social exclusion in humans (DeWall & Baumeister, 2006) as well as with a vast literature demonstrating stress-induced hypoalgesia in response to social distress in animals (Butler & Finn, 2009). A central advantage of this study was its use of a confederate to give participants a live interaction that was as close to real life as possible under controlled conditions. Hypoalgesia occurring in the context of a commonly occurring daily experience suggests that social stressors need not be severe to prompt important physiological changes, and that these responses may be occurring with greater frequency than commonly realized.

The social exclusion participants experienced in Study 1 was of a particular type: a failure to achieve a social connection with another person. Study 2 was designed to ascertain whether the effects observed following the exclusion treatment in Study 1 (which was arguably an implicit exclusion) would extend to explicit exclusion. For reasons that are not clear, neither implicit nor explicit exclusion had any effect on pain in Study 2, thereby failing to replicate the results of
Study 1. The methodology, in which participants were asked to imagine episodes of either implicit or explicit rejection may be one reason. A qualitative review of participant narratives hinted at efforts to minimize the threat associated with the rejection events. Considering Studies 1 and 2 together, it is tempting to conclude that imagining a socially excluding event is not as powerful as experiencing one in the moment. Thus the question remains as to whether an explicitly excluding event can induce an effect on physical pain as it did following the implicitly excluding social exchange in Study 1.

Studies 1 and 2, as well as prior literature investigating the relationship between social connectedness and physical pain, have examined the effects of experimentally induced social exclusion treatments on the perception of experimentally induced acute pain stimuli in healthy participants. Study 3 is the first study I know of to investigate the mutual influence of social connectedness and pain in the daily lives of a sample of chronic pain patients. For reasons that are unclear, the measure of social connectedness used in Study 3, social satisfaction was not associated with concurrent pain and only marginally predicted later pain. Thus, similar to Study 2’s findings, social connectedness did not appear to be reliably linked to pain sensitivity. There may not have been a sufficient number of social exclusion episodes to detect an effect of such events on pain and, as mentioned in the Study 3 discussion, the use of an event-contingent design together with smartphone diaries would go far toward circumventing this limitation of Study 3.

The longitudinal design of Study 3 enabled the investigation of a question that had so far not received attention in the social pain literature: while certain forms of social exclusion have been shown to alter the perception of physical pain (DeWall & Baumeiser, 2006; Eisenberger et al., 2006; Study 1), what might be the effect of physical pain on the perception of a socially excluding interaction? Contrary to prediction, pain was not related to social satisfaction (i.e.,
connectedness) concurrently, nor did pain predict increases or decreases in later reports of social satisfaction. Despite the null findings in Study 3, the relatively small sample size and the limited number of social factors (social satisfaction and emotional closeness) may not have been sufficient to detect differences across levels of pain. In Study 4, participants either in pain or not in pain watched a video of two participants engaged in either a positive or negative exchange. Multivariate analyses showed that whether or not participants were in pain made no difference to any of the social perception factors. These results, therefore, were consistent with Study 3’s null results.

In sum, the four studies reported here have yielded inconsistent results. Study 1 demonstrated that a live, socially disconnecting interaction with another individual can impact the perception of subsequently applied pressure pain stimuli. However, the results from Studies 2, 3, and 4 failed to find any relationship between the two types of pain. The notion of social pain holds that the distress arising from social exclusion is accompanied by a pain-like feeling, which arises because of the biological and neural mechanisms it shares with physical pain. Most importantly, this social-physical pain overlap encourages the development of two hypotheses: One hypothesis is that sensitivity to one type of pain predicts sensitivity to the other type. Support for such hypotheses have been clear (Eisenberger et al, 2006; Way et al, 2009). The other hypothesis is that the introduction of one type of pain will affect the perception of the other type. Evidence pertaining to this second hypothesis has been more equivocal, with some findings showing that social distress is associated with an increase in physical pain (Eisenberger et al, 2006), others showing a decrease in physical pain (DeWall & Baumeister, 2006; Study 1), and still others showing no effect on physical pain (Studies 2 and 3). Taken together, then, the picture that has emerged from the published literature and from these four studies suggests that the phenomenon
of social pain and its relationship with physical pain may be more complex and involve a broader range of factors than previously realized. On the one hand, the evidence of shared sensitivity to social and physical pain seems to be strong support for the postulate of social-physical pain overlap. On the other hand, the equivocal results pertaining to the effect of one type of pain on the other type suggests that numerous processes become involved when threat or injury occurs. For example, the threat of social disconnection may trigger a freeze-flight-fight response (Bracha, 2004; Gray, 1988) in turn producing opioid mediated stress-induced analgesic effects. Such effects could occur independently of whether social and physical pains share biological substrates. Thus, the effects that one type of pain may have on the other most probably emerge out of an interaction of multiple factors, only one of which is shared processing.

It is important to point out that the physical pain system consists of two complementary systems (Bingel et al, 2007). One is the ascending (or simply pain) system, which is responsible for the invocation of the pain experience, and is associated with particular brain areas such as the thalamus, ACC, insula and somatosensory cortex (Lee & Tracey, 2010; Apkarian et al, 2005). Each of these regions contribute a different element to the overall pain experience. Second is the descending (or anti-pain) system, whose job it is to modulate pain, and is associated with other brain regions such as the prefrontal cortex, periaqueudctal gray and the rostral ventral medulla (Bingel & Tracey, 2008). Importantly, the anti-pain system can be influenced by numerous situational factors such as the controllability, meaning, emotional context, and severity of the threatening situation (Salomons et al, 2004; Rhudy et al, 2008; Barkwell, 1991). These two systems function together. One’s pain experience is dependent on the interplay between both. A useful analogy is a radio. Activation of the ascending system is akin to turning on the radio, whereas modulatory circuits provide a kind of volume dial to adjust just how “loud” the pain
gets. This balance between pain and anti-pain systems is adaptive and makes sense from an evolutionary perspective. Sometimes pain is adaptive, whereas at other times pain is maladaptive. Being hobbled by pain might reduce the chances of survival while in the midst of a threat but once the threat has passed, pain becomes more adaptive as it encourages protection and the promotion of healing. The football player who can finish a game with minimal pain after fracturing an ankle but who feels the full brunt of his injury after stepping off the field is an example of this pain/anti-pain balance.

As indicated above, brain imaging studies of physical pain have revealed that activity in brain regions relating to the regulation of pain (e.g., the prefrontal cortex) tend to occur alongside activity in the ascending circuitry (e.g, the ACC and insula). Now, evidence from brain imaging studies has shown that pain/anti-pain coordination is likely involved in the case of social pain as well. Studies by Eisenberger et al (2003; 2006) have shown that PFC regions are active along with the ACC and insula during the occurrence of socially painful events and that PFC activity is negatively correlated with ACC responses and negatively correlated with subjective reports of distress.

Thus to the extent that there is overlap in the neural and biological systems underlying social and physical pain, the involvement of both ascending and descending systems should be seen for social pain as well as physical pain. Given common systems underlying social pain and physical pain, there is no reason to expect that social pain should function any differently. To verify this, however, future studies involving social pain will need to explore the extent to which anti-pain systems are involved in pain outcomes. For example, as opioids are often implicated when descending pain modulation occurs (Millan, 2002), it would be illuminating to replicate Study 1 but with opioid blockade (e.g., with naltrexone) to determine if pain inhibition is eliminated and
to see whether hypoalgesia is replaced with hyperalgesia due to the priming of social pain on the pain system.

In sum, it would be tempting to conclude that the four studies reported here call into question the assertion that there is considerable commonality between the neurobiological systems mediating both social and physical pain. Although the negative social encounter with the confederate had an effect on pain sensitivity, Studies 2, 3 and 4 revealed no relationship between social and physical pain experiences. I would assert, however, that most warranted conclusion is that the phenomenon of social pain is more complex than previously conceived. It is becoming increasingly evident that physical pain is a complex adaptive system, involving numerous subsystems that interact in intricate ways and that is influenced by scores of contextual factors. It should not be surprising, therefore, that social pain would be similarly complex. The construct of social pain is an important one and there remains many questions. In the next section I identify what I believe are some of the most pressing questions to be addressed in future research accompanied by suggestions on the means by which these questions can best be addressed.

2 Questions and Issues to Address in Future Research

2.1 Q. 1: How to operationalize social pain?

One potential limitation of this program of research has to do with the measurement of social pain. The measurement of physical pain has widely acknowledged limitations (Turk & Melzack, 2001; Frampton & Hughes-Webb, 2011), yet a number of pain measurement approaches have become accepted practice in the literature. One very commonly used method is to rate aspects of
a pain experience, such as intensity and unpleasantness, using a numeric rating scale, from 0 (none at all) to 10 (worst imaginable). This is the method adopted in this thesis research. But while there are established methods of operationalizing and assessing physical pain, no such methods have emerged in the social pain literature. For example, in research by Eisenberger, Lieberman and Williams (2003) and Eisenberger, Jarcho, Lieberman, & Naliboff (2006), participants were given a questionnaire measuring “social distress”, which included items assessing self esteem (“I felt liked”), belongingness (“I felt rejected”), meaningfulness (“I felt invisible”), and control (“I felt powerful”). Since the authors promote their data as supporting the notion of social pain, the implicit assumption is that such a measure encompasses a pain-like element. This assumption is questionable. This lack of agreement on what characteristics define social pain seriously hampers the interpretation of the results from studies investigating the implications of the possible social-physical pain overlap.

Unfortunately, this thesis research has done little to rectify the situation. None of the four studies employed a measure of social disconnection that directly assessed a pain-like element. For example, in Study 1, the social connectedness questionnaire included items that attempted to gauge how much participants liked and felt close to the confederate. Low ratings on this measure were taken to reflect disconnection. But as indicated, feeling disconnected does not necessarily involve an element of emotional pain. Progress in this field necessitates that the distinction between social exclusion and social pain be examined further and that instruments be developed that provide valid measures of social pain.

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28 Either experimentally induced or naturally occurring as in chronic pain patients.
2.2 Q. 2: What happens to the perception of the first pain after application of the second?

In Study 1, the manipulation entailed a live interaction with a confederate and in Study 2, the manipulation consisted of the construction of a socially painful experience in the imagination. A social pain manipulation was administered and social connectedness assessed. In both cases, physical pain was added after the occurrence of a social pain manipulation and the perception of this second pain was measured and then compared with physical pain measures occurring before the social pain manipulation. This paradigm is consistent with the extant literature pertinent to social pain (DeWall & Baumeister, 2006; Eisenberger et al, 2006). However, the perception of the first pain (social pain) was never re-assessed, which left open the question as to what effect the physical pain might have had on any lingering sense of social pain. It would be valuable to ask participants for retrospective reports of the initial social pain experience (e.g., Nordgren, Banas & MacDonald, 2011, Study 4). Collecting this additional piece of information would be easy and examining the changes to both the second and first pains within-participants may uncover additional hints as to the dynamics and feedback loops potentially operating between social and physical pain. In Study 1, for example, physical pain reported during the post-manipulation pain test decreased relative to pre-manipulation levels but it is not known whether the physical pain test stimuli themselves might alter the retrospective perception of their social disconnection.

2.3 Q. 3: What factors mediate the effect of social disconnection and physical pain?

In both DeWall and Baumeister (2006) and the current Study 1, manipulations designed to induce feelings of social disconnection provoked hypoalgesia. To ascertain the mechanisms behind this effect, self-report measures of emotional responses were examined and found to not
mediate the observed hypoalgesia. Future studies should focus more on specific mechanisms mediating the effect of a socially stressful evening on pain inhibition in DeWall and Baumeister (2006) and Study 1. Examples of specific mediating factors include stress-induced hypoalgesia, attention effects (e.g., the presence of the social pain distracted from the physical pain stimuli), and psychophysiological phenomena (e.g., a particular level of physical pain stimuli in the presence of social pain may be perceived as less intense compared to the same level of physical pain stimuli administered to a person who has no pre-existing social pain). Additional candidate factors include specific emotions (despair, shame, depression, etc.), cognitive factors (sense of control and escapability, frustration, etc.), behavioral reactions (seeking to connect with another given the opportunity), and physiological responses. Building a model of mediating factors will help to illuminate not only why hypoalgesic effects were observed in DeWall and Baumeister (2006) and Study 1, but also why such effects were not observed in Studies 2 or 3.

2.4 Q. 4: What are the physiological sequelae of social disconnection?

Physiological measures have been conspicuously absent from the social pain literature, yet they hold great potential to improve our understanding of social pain phenomena. It is possible that one pathway by which social stressors impact pain (and vice versa) is via routes that operate below conscious awareness and are therefore inaccessible for conscious report. Objective measures that index autonomic responses such as skin conductance, cardiovascular indices and startle responses could provide a crucial window into autonomic and other systems that operate outside awareness. Establishing the physiological sequelae of social disconnection and how these may differ depending on individual differences and the varying characteristics of the socially disconnecting events stands to help reveal a great deal about the complexities underlying the
relationship between social experience and physical pain. Unfortunately, in this research, time and budget constraints precluded the capture of physiological indices such as heart rate, blood pressure and skin conductance. The chief hypothesis as to why pain inhibition was observed in Study 1 was that the negative interaction with the confederate was sufficiently threatening so as to provoke the stress response, which entails pain inhibition. In Study 2, the lack of an effect of imagining rejection events raised the possibility that the manipulation was not potent enough to provoke the threat response. In both cases, physiological measures would have been highly valuable in gaining insight into the processes mediating the hypoalgesic effect under one set of conditions (in Study 1) and the lack of any pain effect under another set of conditions (in Studies 2 and 3).

3 The Need to Expand in Vivo Research

Studies 1, 2 and 4 all employed contrived experimental manipulations in artificial environments. The tight control afforded in these experiments represents an advantage for internal validity (Cozby, 2004), and indeed has been the dominant method in the literature investigating the effects of social exclusion. But much of the complexity that is stripped away in controlled lab experiments may represent important forces relevant to the phenomena under investigation and therefore their absence may seriously hamper the ecological validity of the results. This problem may be especially acute in cases where social relationships are studied, due to their inherently complex nature.

Study 3 represented an attempt to expand the investigation of the relationship between social disconnection and physical pain within the complex social environment and demands of daily life. The failure of Study 3 to uncover any relationships between the measures of disconnection
used in that study (social satisfaction and emotional closeness) and physical pain may be due to numerous features of that study. Nonetheless, the methodology along with rapidly evolving mobile health tracking technologies present many exciting possibilities. Future research should exploit these possibilities. I believe that each of the questions addressed by Studies 1, 2 and 4 can and should be pursued using an in vivo approach, which would enable the achievement of unique insights not otherwise possible. For example, instead of devising experimental manipulations that induce various types of social exclusion as was done in Studies 1 and 2, participants could simply use a Smartphone to answer some details regarding the nature of the socially excluding events whenever they occur in their daily lives, including details of the event, how it made them feel and their physical pain levels. In addition to providing an easy means of capturing participant-provided responses to questions, capabilities built into most Smartphones available today could automatically record a bevy of objective measures such as time, location (via GPS), and activity level (via accelerometer), and inexpensive portable peripherals can record physiological indices such as heart rate, blood pressure, and skin conductance levels. In this way, the rich complexity of factors surrounding excluding social experiences can be preserved and mined. In this thesis, Studies 1 and 2 inquired into the effects of socially disconnecting experiences on physical pain, whereas Study 4 endeavored to examine the effects of physical pain on the perception of socially disconnecting experiences. The separate participants (between-subjects design), methodologies, and measures used in each study make it difficult to directly examine how social and physical experiences might influence each other in feedback loops. On the other hand, in vivo studies, such as Study 3, provide the means by which these bidirectional dynamics can be examined more directly and within individuals.
4 Unique Contributions

This thesis research has made several unique contributions. First, it was the first pain-related study to use a confederate to provoke social disconnectedness through a live interaction with another human being. Although other studies have shown an impact of social disconnection on pain (Eisenberger et al, 2006; DeWall & Baumeister, 2006), none have done so in response to an ecologically valid manipulation as was done here. The research reported here therefore represents an important advance. Hypoalgesia occurring in the context of a commonly occurring daily experience suggests that social stressors represent salient threats that can provoke a range of potent physiological responses, and that these responses may be occurring with greater frequency than commonly realized.

Second, this thesis research was the first to investigate the influence of physical pain on responses to social perception not only in reaction to experimentally induced physical pain in generally healthy participants but also to long-lasting pain (in chronic pain patients) on the social perceptions of every day social interactions. While diary methods have been employed in exploring psychosocial factors in people with chronic pain (Follick et al, 1984; Jamison et al, 2001; Viane et al, 2004; Massey et al, 2009; Badr et al, 2010), this research was the first to investigate the relationship between feelings of social connectedness within the context of the real social interactions in the everyday lives of people living with chronic pain over a period of several weeks.

Finally, I developed an innovative method of inducing pain in healthy individuals that permitted the intensity and duration of painful stimulation to be relatively carefully controlled. This research employed a novel sensitization strategy by which a relatively low concentration of
capsaicin (.075%) was applied to the skin causing only thermal allodynia with mild, if any pain. Greater pain intensity was achieved by increasing the temperature of the heat applied to capsaicin treated skin; the duration of the pain could be easily controlled by merely keeping the heat applied for as long as the pain was desired, and terminated by removing the heat. This novel method of experimentally inducing pain allows for much greater flexibility than most current methods and has the potential to be useful for pain research. One advantage is that it enables the duration of pain to be precisely controlled and even manipulated. For example, a researcher can ask what effects psychological treatments have on pain when the duration of pain is varied; or pain can be turned on and off at different points throughout the experiment thereby enabling within-participants comparisons across experimental conditions. Another advantage is that since even long-lasting experimentally induced pain (in excess of 20 mins) can be immediately terminated at any time, participants are less likely to feel anxiety, which would diminish a potential confound.

5 Conclusion

Piglet sidled up to Pooh from behind. "Pooh!" he whispered. "Yes, Piglet?" "Nothing," said Piglet, taking Pooh's paw. "I just wanted to be sure of you."

~A.A. Milne

That humans are supremely social beings has been made starkly apparent by a voluminous body of empirical evidence showing that social disconnection in various forms (isolation, loneliness, insufficient social support, conflict, etc.) has been linked to a multitude of health maladies and even shortened lifespan. But there is one health problem in particular that has been demonstrated to have a particularly intimate link with social disconnection: pain. Chemical and brain imaging
studies in animals and humans, respectively, have shown that social pain – the emotionally painful experience following a socially disconnecting event – shares biological and neural substrates with physical pain. An overlap of sort suggests several intriguing consequences that have begun to be investigated (Eisenberger et al, 2006; DeWall & Baumeister, 2006; Way, Taylor & Eisenberger, 2009). The program of research reported here has endeavored to expand the exploration of these consequences in novel ways. Over four studies, this research has employed novel methodologies in distinct populations to examine the bidirectional dynamics between social and physical pain. As the quotation from A.A. Milne above suggests, we have a strong need for connection with others and to “be sure” that these connections remain strong and vital. This dissertation research has endeavored to advance our understanding of what happens when social and physical pains intersect in humans.
References


To help the U of T frosh-week committee assess the usefulness of the social activity you just participated in, we would greatly appreciate your feedback.

The questions on this page ask about your assessment of the outcome of the social exchange you had with the other participant. For each question, please CIRCLE a number from 1 to 9, noting the endpoints indicated above the numbers. For example, for the first question, you would circle “1” if you didn’t click at all with your partner, “9” if you clicked very much, or some number in between depending on how much you clicked with your partner.

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How much do you feel you <strong>clicked</strong> with your partner?</td>
<td>1 = didn’t click at all. 9 = clicked very much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>2</td>
<td>How <strong>close</strong> do you feel to your partner?</td>
<td>1 = not at all close. 9 = very close</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>3</td>
<td>How <strong>similar</strong> do you feel your partner?</td>
<td>1 = not at all similar. 9 = very similar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>4</td>
<td>How much do you <strong>like</strong> your partner?</td>
<td>1 = do not like at all. 9 = very much like</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>5</td>
<td>In the future, to what extent do you feel you could be <strong>friends</strong> with your partner?</td>
<td>1 = not at friends. 9 = very much friends</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>6</td>
<td>To what degree do you feel your partner <strong>understood</strong> you?</td>
<td>1 = not at all understood. 9 = very much understood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>7</td>
<td>To what degree did you <strong>enjoy</strong> the exchange?</td>
<td>1 = not at all enjoy. 9 = very much enjoy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>8</td>
<td>To what degree do you feel <strong>positive</strong> about the exchange?</td>
<td>1 = not at all positive. 9 = very much positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
</tbody>
</table>
Appendix B
Diary items

Note: Questions 1 and 2 were included only in the diary section pertaining to the most recent social event. Questions 3 – 9 were included in the diary section pertaining to the most recent social event and then repeated in the diary section pertaining to the most recent non-social event.

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How many people were you with?</td>
<td>1 to &gt; 10</td>
</tr>
<tr>
<td>Note: Participants selected number of individuals within each category of relation (family, friend, neighbor, etc.)</td>
<td></td>
</tr>
<tr>
<td>2. How emotionally close did you feel with each type of relation?</td>
<td>1 (not at all) to 11 (very much)</td>
</tr>
<tr>
<td>Note: Analyses in this report used the mean emotional closeness across relationship types.</td>
<td></td>
</tr>
<tr>
<td>3. How pleasurable for you was the [social interaction/activity]?</td>
<td>1 (not at all) to 7 (very much)</td>
</tr>
<tr>
<td>4. To what degree did you feel stressed during the [social interaction/activity]?</td>
<td>1 (not at all) to 7 (very much)</td>
</tr>
<tr>
<td>5. To what degree was there conflict during the [social interaction/activity]?</td>
<td>1 (not at all) to 7 (very much)</td>
</tr>
<tr>
<td>6. How socially connected did you feel during the [social interaction/activity]?</td>
<td>1 (not at all) to 7 (very much)</td>
</tr>
<tr>
<td>7. During the [social interaction/activity], rate pain intensity and pain unpleasantness. Pain intensity refers to the objective measure of SEVERITY of pain, while pain unpleasantness refers to the subjective measure of how BOTHERSOME it was for you. (2 items)</td>
<td>1 (Not at all) to 11 (very much)</td>
</tr>
<tr>
<td>8. During the [social interaction/activity], please rate the degree to which you felt each of the following, specifically pertaining to your pain. For example, rate how frustrated you feel relating to your pain, not to problems unrelated to pain. (6 items)</td>
<td>1 (Not at all) to 11 (very much)</td>
</tr>
</tbody>
</table>
During the [social interaction/activity], to what degree would you say that your pain was preventing you from performing the activities you wanted/needed to do? In other words, how intrusive was your pain?

In a diary section separate from the questions pertaining to either the most recent social or non-social event, participants were asked about their overall wellbeing during the diary period (morning, afternoon, evening):

How would you describe your overall well-being? 1 (Poor) to 7 (Excellent)

Morning diaries (only) included the following:

Please rate your quality of sleep last night. 1 (Very poor) to 11 (Very good)

Please enter your amount of sleep last night (in hours, between 0 and 16). Free entry

Evening diaries (only) included the following:

Relative to your normal daily pain medication usage, would you say that you took less, about the same, or more than you usually do? 1 (Much less) to 7 (Much more)
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