Shared neural circuits: The connection between social and physical pain

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Abstract

Interpersonal rejection, exclusion, and loss are known to produce painful feelings (Eisenberger, Lieberman, & Williams, 2003), but little is known about the neural network underlying this type of pain. Recent evidence suggests this social pain may have important neural connections with physical pain (Eisenberger et al., 2003). The current literature review explores the connection between social pain and physical pain in neural activity, individual differences (e.g., pain sensitivity), situation appraisal, social support, and pain reducers (e.g., acetaminophen). The review examines the overlapping pain system as an evolutionary adaptation necessary for survival (MacDonald & Leary, 2005). Authentic experiences of social rejection (e.g., bullying) are explored and offer new directions for research (Sansone, Watts & Wiederman, 2013), and opposing evidence supporting a numbing effect of severe social rejection is discussed (Berstein & Claypool, 2012). The review concludes with a synthesis and discussion about why understanding social pain is important.

Keywords: Cyberball, exclusion, ostracism, physical pain, rejection, social pain

Introduction

The experience of social rejection is universal. Some people experience only occasional social rejection and have adequate social support to maintain a sense of connection to others. For others, however, social rejection is a common experience in the form of bullying, difficulty making and keeping friends, and experiencing the loss of close loved ones. Whether social rejection is common or infrequent, the perceived experience of social rejection results in a pain response – called social pain. Since humans are innately driven to belong and form lasting social connections, the disruption of this need for acceptance results in social pain and has profound and long-lasting negative consequences (Baumeister & Leary, 1995; Cacioppo, Hawkley, & Thisted, 2010; Slavich, O’Donovan, Epel, & Kemeny, 2010). Understanding the neural system underlying social pain is of critical importance for the field of psychology, as it will assist in determining how individuals perceive and experience pain in relation to other people.

Linking Social Pain and Physical Pain

The idea that social rejection results in negative emotions is reminiscent of the idea that a physically painful experience (e.g., getting a paper cut) results in negative feelings. Expressions often used to convey this emotional distress, such as “that hurt my feelings,” also take on language typically used to explain experiences of pain (Eisenberger, 2012a). While this interplay of emotional pain and physical pain takes place metaphorically in language, recent research shows that these two types of pain may be more related than previously believed and may share a neural pain system (Eisenberger, Lieberman, & Williams, 2003). The similarities between the experiences and neural activation of physical pain and social pain resulting from rejection support the theory that they share a pain system, ultimately suggesting that the
experience of social pain is as real and intense as physical pain. (Eisenberger & Lieberman, 2004; Eisenberger et al., 2003; Hirsch, & Downey, 2007; Kross, Egner, Ochsner,). This evidence-based theory of overlapping neural pain circuits has gained attention in the field, prompting the current review.

We first explore the link between social pain and physical pain by examining the potential evolutionary development of a shared pain system and then identifying neurological areas of the brain implicated in the activation and regulation of pain. The review then identifies the individual differences, such as attachment style (DeWall et al., 2012) and self-esteem (Onado et al., 2012), that influence the perception and experience of social pain and physical pain. Other factors relating to the increased sensitivity or regulation of pain are explored, such as social support (Masten, Telzer, Fuligni, Lieberman, & Eisenberger, 2012) and substances that work to buffer the experience of social pain (Deckman, DeWall, Way, Gilman, & Richman, 2013; DeWall et al., 2010). We then analyze authentic experiences of social rejection or loss, such as bullying (Sansone & Sansone, 2008) or the death of a loved one (Gündel, O’Connor, Littrell, Fort, & Lane, 2003). Next is an examination of a numbing reaction in response to severe social pain and severe physical pain (Bernstein & Claypool, 2012; DeWall & Baumeister, 2006) and a conclusion discussing the limitations of current research and ideas for future research.

The growing body of evidence suggests that pain resulting from rejection is processed and experienced similarly to physical pain, however there is still much to learn about the connection and divergence between social and physical pain systems. The current review explores the shared pain system through the neurological, individual, environmental and experiential aspects of social and physical pain.

**Evolutionary Perspective of Shared Pain Circuits**

Do physical pain and social pain share neural circuits? This is a compelling question since shared circuitry would suggest that physical pain and social pain could be equally painful and perhaps equally threatening to individuals’ health and well-being. The shared neural circuitry idea between physical pain and social pain can be explained as evolutionarily adaptive. During infancy, mammals learn that social exclusion and abandonment by a mother poses the risk of physical danger and pain (Eisenberger & Lieberman, 2004). The resulting dependency on the mother for safety and need satisfaction is part of the development of the mother-infant bond, as proposed by Bowlby (1958). The extended period of dependence that young humans have on their mothers, relative to other animals, suggests the adaptive advantage of a pain system that detects not only physical danger but social threats that might foreshadow harm (e.g., abandonment or rejection). This evolved overlapping system would allow humans to quickly recognize threats of social separation and danger, which would be cued by social pain resulting from rejection (Eisenberger & Lieberman, 2004). While this evolutionary perspective proposes a compelling explanation of why social and physical pain systems overlap, it is merely a theoretical perspective that cannot be studied empirically.

**Neurological Regions Implicated in Pain**

Examining brain activation during
experiences of rejection and physical harm is the first step in understanding how pain is processed and perceived. Analyzing the similarities and differences between the neurological processing of social pain and physical pain is an important component of evaluating the theory of shared neural pain systems. fMRI studies have implicated multiple regions of the brain in processing and regulating social pain through use of a variety of social exclusion tasks. We now turn to a review of some of the primary areas identified as relevant to the neurological physical and social pain processes, learned through Cyberball and other methodologies.

**Activating Pain Response**

**Anterior cingulate cortex.** Research has established the anterior cingulate cortex (ACC) and the anterior insula as important neural regions involved in the affective aspect of pain, the emotionally distressing aspect of pain, not pain sensation (Eisenberger et al., 2003; Masten et al., 2012). The ACC is located near the frontal part of the corpus callosum in the medial frontal lobe and the anterior insula is part of the insular cortex. The fact that the ACC is active during the experience of unpleasantness suggests it may play a role in the processing of social pain signals.

Other areas of the brain, specifically the secondary somatosensory cortices and the posterior insula, are understood to be involved in pain sensation, rather than processing (Eisenberger, 2012a). Lesion damage to one of these areas of the brain correlates with a loss of either physical pain sensation or pain affect. For example, patients with chronic physical pain who undergo a procedure to lesion an area of the dorsal anterior cingulated cortex (dACC) report the ability to localize pain and feel physical pain sensation, but do not feel the unpleasantness of pain (Eisenberger, 2012b). On the other hand, individuals with lesions on the somatosensory cortices lose the ability to localize pain but still experience the emotional aspect of pain (Eisenberger, 2012b).

The ACC has also been implicated in expectancy violation (Cacioppo et al., 2013; Eisenberger & Lieberman, 2004; Eisenberger et al., 2003) and grief after a significant loss of a loved one (Gündel et al., 2003). Expectancy violations may come in the form of unexpected social rejections and grief from loss can involve social abandonment that may feel similar to rejection. The ACC’s relation to felt unpleasantness in pain is important because it allows researchers to localize neural activity and responses to social pain.

**Dorsolateral anterior cingulate cortex.** A specific area of the ACC, the dorsolateral anterior cingulate cortex (dACC) is particularly associated with the affective aspect (e.g., crying, sadness) of both social and physical pain. The dACC is thus involved in the negative emotional response people might experience from being socially excluded or physically hurt. In support of this theory, increased activity in the dACC has been strongly related with self-reported pain unpleasantness (Eisenberger & Lieberman, 2004). In other words, the dACC has been found to be active in experiences of social rejection or exclusion that resulted in people’s experiences of unpleasant and negative emotions.

A majority of studies utilize an electronic method of eliciting social pain called Cyberball. Cyberball is a laboratory game developed by Williams, Cheung, and Choi (2000) in which participants are randomly assigned to be included in a computer ball tossing game by other
ostensibly real players, completely excluded from the game, or partially excluded in the game. Experimental fMRI studies using Cyberball have supported the theory that dACC activation is representative of the social pain experience. During the Cyberball task, the dACC is more active when individuals are socially excluded versus included (Eisenberger & Lieberman, 2004; Eisenberger et al., 2003). This neural activation of the dACC in experiences of social exclusion, but not in experiences of social inclusion, demonstrates its important role in localizing the experience of social pain. Research has also examined whether the type of social exclusion in Cyberball is related to a different experience of social pain by comparing conditions of explicit exclusion (i.e., excluded by other players) and implicit exclusion (i.e., excluded due to extenuating circumstances such as technical difficulties). These studies found that while both explicit and implicit exclusion elicits social pain and dACC activation, social pain is more severe in explicit social exclusion because it elicits a greater pain regulating response (Eisenberger et al., 2003).

### Regulating Pain Response: Right Ventrolateral Prefrontal Cortex

The experience of pain can be self-regulated through the neural system processing pain signals. The regulating response to pain functions to inhibit the potential painful effects of an aversive experience. Neuroimaging studies have implicated the right ventrolateral prefrontal cortex (rVLPFC) in this pain regulating response, an area typically associated with executive functions such as planning, decision-making, and problem solving. Understanding the similarities in the self-regulation of social pain and physical pain can further explain the overlapping neural circuitry involved in the shared pain system.

#### Neural alarm system

The pain system has been theorized as a neural alarm system working to detect danger and potential threats. In this model the dACC functions as a neural alarm to alert individuals to error and conflict. The rVLPFC fits into system by adaptively turning off the neural alarm once the individual has attended to the conflict. This allows more important stimuli to be responded to once the threat is over (Eisenberger & Lieberman, 2004; Eisenberger et al., 2003). Thus, the rVLPFC is thought to regulate activation of the dACC and reduce or control pain resulting from social rejection and physically painful stimuli.

#### Social pain and physical pain regulation

Neuroimaging studies have implicated the rVLPFC in regulating both social pain and physical pain. A study utilizing PET imaging with individuals suffering from chronic abdominal pain found that increased activation of the rVLPFC is related with fewer self-reported symptoms of physical pain following a placebo regimen (Lieberman et al., 2004). These findings suggest that the rVLPFC regulates the intensity of physical pain. Research about the regulating response of social pain mirror the findings of studies about the role of the rVLPFC in physical pain, supporting the theory of a shared neurological pain system. Riva, Lauro, DeWall, & Bushman (2012) found that direct stimulation of the rVLPFC reduces the affective aspect of social pain as a result of exclusion in Cyberball. In other words, people who experience increased activation of this area have a buffered reaction to social rejection. Similarly, activation of the rVLPFC during social exclusion in Cyberball was found to have an inverse relation with activation of the dACC and self-reported felt-unpleasantness.
(Eisenberger & Lieberman, 2004; Eisenberger et al., 2003). Like physical pain, the effect of rVLPFC activation on social pain is mediated by dACC activity. These findings suggest that the rVLPFC works to regulate the affective and unpleasant aspect of pain by reducing activation of the dACC and helps us understand the complexity of the shared neural pain system.

Individual Differences Involved in the Experience of Pain

If we are to fully appreciate the underlying neural networks that connect physical and social pain, we need to consider the diversity that characterizes the human pain experience. Individuals experience social and physical pain differently, varying in level of pain tolerance and sensation, as well as varying in types of experiences that may trigger severe pain. Cognitions and appraisals, including how vividly people might imagine social or physical pain, influence the experience of pain and underscore the importance of contextualizing pain. Differences in self-esteem and mood (e.g., depression and anxiety) appear to play a large role in the experiential part of social rejection, as well their responsiveness to punishment and reward. All of these individual differences relate to the question of how connected neural networks for physical and social pain might be. We now turn to a review of pain sensitivity and other individual differences to understand the complex and varied relationship between social and physical pain.

Sensitivity to Pain

Just as one person is able to hold a hot cup of coffee that other people find holding physically uncomfortable, all individuals have different levels of tolerance for pain and thresholds for pain sensitivity. The variability in pain sensitivity is most evident in physical pain; however, it is also relevant to social pain. Research has shown that people may prefer physical pain over social pain, suggesting that social pain may actually be more aversive than physical pain (Williams & Zadro, 2005). Given the overlapping social and physical pain system, individuals with high pain sensitivity should be more sensitive to both physical and social pain. Consistent with this idea, rejection sensitive individuals (i.e., people more prone to experience social pain from rejection) report more distress than non-rejection sensitive individuals when watching subjects on film experience physical pain (Eisenberger & Lieberman, 2004). The reverse pattern is also supported. Individuals who experience more pain through physical harm also report higher levels of distress after social exclusion, even after controlling for anxiety and neuroticism that may influence responses due to negative affect (Eisenberger, 2012b). Similarly, when individuals are given an endotoxin to induce an inflammatory response, resulting in physical pain, report feelings of increasing social exclusion (Eisenberger, 2012b). These findings suggest that individuals experience similar sensitivity and tolerance to both social and physical pain, supporting the theory that these two types of pain are processed similarly.

Vivid Mental Imagery and Imagined Future Pain

The ability to use one’s imagination is a skill that varies along a continuum. It has been proposed that the ability to imagine experiences of pain would be related with the level of pain experienced because of the amount of emotional arousal (Chen & Williams, 2012). While a majority of research has supported how experiences of
social pain and physical pain are similar, recent research found a difference between physical pain and social pain in regards to pre-living pain through imagination. This difference offers evidence opposing the theory of shared neural pain systems. Chen and Williams (2012) found that individuals experienced more pain when imagining future social pain, such as a betrayal by a romantic partner, compared to imagining future physical pain, such as a physical injury. These findings suggest that just as remembering a past social exclusion is more painful than recalling a past physical injury, pre-lived social rejection is more painful than a pre-lived physical injury. The ability to imagine experiences in more detail with vivid mental imagery was found to be associated with increased social pain, but not physical pain, further suggesting a divergence in the social and physical pain system (Chen & Williams, 2012). While there is considerable evidence suggesting an overlap in the neurological pain system, it must be recognized that there are potential differences between the neural processing and experience of social pain and physical pain.

**Self-Esteem**

**State and trait self-esteem.** One well-documented individual difference variable that appears related to people’s experiences of social pain is self-esteem. Self-esteem involves both the short-term, immediate feelings one has about oneself (i.e., state self-esteem) and the long-term global beliefs one maintains about one’s self-concept over time (i.e., trait self-esteem; Onoda et al., 2010). While scholars typically cite self-esteem as a protective factor for psychological well-being (Dumont & Provost, 1999), it may instead more closely relate to how people experience social inclusion, which in turn relates to psychological well-being (Eisenberger & Lieberman, 2004). Research has shown that trait self-esteem – theoretically based upon past inclusion and exclusion experiences, physical attractiveness, intelligence, and other desirable traits – mediates social pain so that individuals with higher trait self-esteem experience less social pain and activity in the dACC when excluded than people with lower trait self-esteem (Onado et al., 2012; Yanagisawa et al., 2011a).

Other evidence also supports the idea that self-esteem plays a role in people’s experience of social pain. Increased trait self-esteem mediates social pain and dACC activation following exclusion, and the relation between social pain and self-esteem is also seen in the other direction, with exclusionary experiences subsequently lowering one’s self-esteem (Eisenberger & Lieberman, 2004). This strong bidirectional relationship between self-esteem and rejection-induced social pain illustrates how important social acceptance is to the development of the self-concept. The bidirectional relationship also suggests that how we feel about ourselves, which is determined in part by past social inclusion and exclusion, plays a significant role in the experience and strength of social pain following a new social rejection. Although evidence suggests that self-esteem is related to the experience of social pain, not all research has replicated these findings. McDonald and Donnellan (2012) found that higher self-esteem was not related to greater satisfied needs after social exclusion, and thus their study does not support the theory that self-esteem buffers social pain.

**Self esteem, introversion, and extraversion.** Some evidence suggests that the relation between social pain and self-esteem may be more nuanced than simple mediation. For instance, the personality
traits of introversion and extraversion appear to also play a role in social pain and physical pain because of their relation to self-esteem. Extraverts tend to have higher self-esteem (Halamandaris & Power, 1997) and are thus likely have lower rejection sensitivity. A review of the literature by Phillips and Gatchel (2000) presented that extraverts also have higher physical pain thresholds and tolerance than introverts who tend to have lower self-esteem. This connection between self-esteem, introversion and extraversion offers evidence that personality traits alter how we perceive our experiences, including the intensity of pain during social rejection and physical harm. This effect may take place because individuals interpret social rejection and feelings of pain in relation to one’s self-concept and how they relate to others. The strong relation between self-esteem and social pain shows the important, if not yet fully understood, role self-esteem plays in experiences of rejection.

Depression and Anxiety

The degree to which individuals experience negative emotions, such as sadness, and possess particular personality traits, such as neuroticism, alters the perception and experience of pain. The seemingly bidirectional relation between experiences that trigger negative emotions, such as depression and anxiety, and physical or social pain is complex and only beginning to be understood. Research has found that social exclusion often results not only in social pain but overall decreased mood and satisfaction (McDonald & Donnellan, 2012). Similarly, individuals with higher anxiety or neuroticism tend to have lower physical pain thresholds and are more rejection sensitive, experiencing a higher likelihood of hurt feelings or negative emotions following exclusion (Phillips & Gatchel, 2000). These relations not only explain possible effects of social pain (i.e., depression), but also show how depression and anxiety might drive higher social and physical pain sensitivity. It seems reasonable that depression and anxiety would relate to increased social pain following rejection (e.g., because of a higher rejection sensitivity); however the relation between depression and anxiety and increases in physical pain intensity is less intuitive. Despite this, depression has been linked with chronic pain disorders and greater likelihood of experiencing more frequent and severe physical pain (Seville & Robinson, 2000).

Depression and anxiety being related to increased frequency and severity of both social pain and physical pain supports the theory of shared neural circuitry by revealing how emotional states seem to alter the experience of pain. This evidence illustrates that the experience of pain is largely psychological, potentially influenced by and influencing one’s emotional state.

Behavioral Inhibition and Activation System

Personality traits may determine the way people relate to others, perceive experiences, and respond to environmental cues, ultimately altering their experience of pain. Two dimensions of personality related to the experience of pain include the sensitivity of perceiving signals of rewards, whether something is desirable and pleasant, and punishment, whether something is unpleasant and harmful. The individual level of responsiveness to punishment and reward may help us understand the neural connection between physical and social pain. Signals of punishment are related to heightened social pain, while signals of reward tend to inhibit social pain. These punishment and reward systems are referred to as the behavioral inhibition system (BIS)
and behavioral activation system (BAS) respectively (Yanagisawa et al., 2011b). The BIS responds to non-reward signals and is related to punishment and feelings of anxiety or sadness. On the other hand, the BAS responds to reward signals and is related to happiness and pleasure (Yanagisawa et al., 2011b). As fitting with the social and physical pain theory, people with greater BIS and punishment sensitivity have been shown to experience more social pain when excluded and exhibit less activity in the rVLPFC (Yanagisawa et al., 2011b). This relationship between punishment-oriented individuals and lowered activity in the rVLPFC accounts neurologically for increased social pain because it is not buffering the social pain as it does for reward-oriented individuals. The lessened activity in the rVLPFC suggests that punishment-oriented individuals experience more social pain from rejection because they have a stronger system for recognizing the negative stimuli and are therefore more rejection sensitive than reward-oriented individuals.

**Attachment Styles**

Adult attachment styles, or how people tend to approach and experience their close relationships, seem to play a role in people’s awareness of and responses to social rejection. Attachment styles are divided into two broad categories: secure and insecure. The secure attachment style reflects a healthy pattern of closeness, dependence, and trust in relationships (Hazan & Shaver, 1987). Insecure styles can be defined as anxious or avoidant. The anxious attachment style describes an intense pursuit for relationship closeness amidst perpetual fear of abandonment, while the avoidant attachment style reflects detachment, distrust, and preference for independence (Hazan & Shaver, 1987). These styles may play a role in the experience of social pain.

Some evidence suggests that individuals with different attachment styles display varying levels of distress in reaction to social disruption and exclusion. For example, individuals high in attachment anxiety are more aware of signs of possible rejection and tend to have more negative reactions to social exclusion involving conflict, separation, and breakups compared to those with more secure attachments (DeWall et al., 2012). Individuals with high attachment anxiety also demonstrate higher activity in the dACC and anterior insula, which suggests an increased experience of pain based on neurological activation (DeWall et al., 2012).

On the other hand, individuals with higher attachment avoidance show decreased activity in the dACC and interior insula (DeWall et al., 2012). This decreased activity can be explained by the tendency for individuals higher in attachment avoidance to distance themselves from others. This interpersonal distance likely lessens the importance of interpersonal relationships or acceptance and helps to explain why they would be less sensitive to either inclusion or exclusion. Similarly, individuals with secure and healthy attachments often have less negative reactions to experiences of rejection. This phenomena will be explored in the form of social support in a later section. Attachment styles, or more generally, the way we relate to other people, play a central role in interpreting and responding to instances of rejection or ostracism.
Situation Appraisal and Threat Evaluation

The subjective level of pain intensity experienced in social pain, more than for physical pain, largely depends on the appraisal of the experience. The process of evaluating experiences, in this case, experiences of social rejection or abandonment, is called situational appraisal. Situation appraisal involves assessing perceived consequences resulting from an experience, judging the threat to one’s well being, and gauging the resources available to cope with the experience (Weisenberg, 1998). Even when a group of individuals experience the same social rejection, such as exclusion in a Cyberball task, individuals appraise the rejecting experience differently, as either more or less personally significant. Subsequently, they experience different levels of social pain. Exclusionary experiences that are appraised as more important result in elevated emotional distress and higher levels of social pain (MacDonald & Leary, 2005). Situation appraisal plays a large role in personal reactions to social exclusion, affecting self-reported levels of pain intensity and likely influencing brain activity following an exclusionary experience.

Social Support

While internal emotional resources, attachment style, and processing systems play a large role in the experience of painful situations, a consideration of situational factors surrounding the experience of physical harm or social rejection may help us more fully understand the way individuals perceive the painful experience. A review of the existing literature would be incomplete without mention of how social support, or a person’s social environment, might shed light on the neural connectivity between physical and emotional pain.

Presence of a Secure Attachment Figure

Support from people close to us often makes difficult experiences less painful. Similar to a secure attachment style, having a secure attachment figure present at the time of social or physical injury lowers the subjective level of pain intensity. While people are unable to take away a loved one’s pain after a severe injury, research has shown that the presence of a secure attachment reduces the pain intensity caused by a physical injury (Master et al., 2009). For example, holding the hand of a secure attachment figure or looking at their picture during a physically painful experience of thermal or electric stimulation significantly lowers the level of physical pain experienced (Coan et al., 2006; Master et al., 2009).

The presence of a secure attachment figure is also associated with lower social pain during exclusion. A recent study even suggests that the presence of a friendly dog may act as a source of attachment to reduce negative emotions during exclusion in Cyberball (Aydin, 2012). Excluded individuals reported a greater sense of acceptance with the dog present, suggesting that excluded individuals are likely to attribute human-like qualities of connection to the dog in place of other people. The presence of a secure attachment figure, however, is not associated with lower activity in the ACC (Karremans, Heslenfeld, van Dillen, & Van Lange, 2011). This may be explained by a lack of increased activity in the hypothalamus, which is activated in similar experiences of stress, when secure attachment figures are present compared to non-attachment figures (Karremans et al., 2011). In other words, this lack of activation
in the hypothalamus suggests that having a secure attachment figure present moderates or alleviates the adverse effects of rejection and stress through the positive feelings of inclusion to the attachment figure (Karremans et al., 2011). On the other hand, a loss of social support in the form of a recent breakup is associated with increased activity in the dACC (Kross, Berman, Mischel, Smith, & Wager, 2011). Social pain can result from separation from others and feeling devalued. Having a secure attachment figure present may be associated with a feeling of acceptance and support from other people which counteracts the negative feelings of rejection and ultimately results in lower social pain.

**Time Spent With Friends**

Social support in the form of time spent with friends is also thought to work as a buffer against future social pain. Masten et al. (2012) found that time spent with friends related to less activity in the anterior insula (an area of the brain associated with social pain) during social exclusion. Spending more time with friends during adolescence, in particular, predicts less social pain resulting from a future experience of social rejection (Masten et al., 2012). This research suggests that spending time with friends may work as a long-term buffer against social pain resulting from social exclusion and that previous sources of support, not just current support, may buffer the adverse feelings associated with ostracism.

**Substances and Material Objects**

Having examined how pain functions differently in people and is determined by situation appraisal and level of social support, we now turn to how other factors commonly involved in social interactions, such as drugs and money, change our experiences of social pain. After a physical injury, people often take pain relievers to reduce their uncomfortable feelings and lower their level of physical pain. Is it possible, given the shared neural circuitry of physical and social pain that commonly used substances to reduce pain, such as acetaminophen or marijuana, also reduce social pain? In addition to substances alleviating both physical and social pain, might having monetary resources be a form of comfort? Recent research has tested these hypotheses offering intriguing evidence that substances and greater monetary resources may buffer the painful effects of social rejection.

**Acetaminophen**

Pain relievers including acetaminophen, such as Tylenol, work by affecting the central nervous system, not the peripheral nervous system. In other words, the drug affects the brain rather than nociceptors at the site of the pain, opening up the possibility that it might also be effective at reducing social pain. DeWall et al. (2010) found that participants who took a daily dose of acetaminophen over a period of three weeks experienced less self-reported daily social pain or hurt feelings. After three weeks of acetaminophen, participants also had significantly less activity in the dACC and right anterior insula following experimentally-induced social exclusion (DeWall et al., 2010). This was the first evidence to suggest that a generic chemical pain reliever can reduce pain in experiences of both physical and social pain, at the neural and self-report level. People who took acetaminophen also showed lowered activity in the amygdala after social exclusion, an area that has been associated with aggression (DeWall et al., 2010). This finding suggests that this common pain reliever may also affect emotional or
behavioral responses to social pain. While acetaminophen should not be used as a means to cope with emotional pain, its effect of reducing social pain following rejection, just as it reduces physical pain, supports the theory of shared pain systems.

**Marijuana**

The use of marijuana as a pain reliever, similar to acetaminophen, has become more popular. It is believed that both marijuana and acetaminophen work to activate the same receptor, specifically CB1, which is theorized as part of the overlapping social and physical pain system (Deckman et al., 2013). While not as effective as anti-inflammatory medications, marijuana and other cannabinoids have been found to reduce nociceptive pain (e.g., pain caused by a burn or stubbed toe) through orally ingested tablets (Campbell et al., 2001), and neuropathic pain (a rare type of chronic pain caused by damage to the nervous system) through smoked cannabis (Ware et al., 2010). Deckman et al. (2013) completed a study involving individuals who smoke marijuana frequently and found that smoking marijuana is related to lower social pain and fewer negative emotions following social exclusion in Cyberball. However, this research did not distinguish between the recreational and medical use of marijuana and does not necessarily support the use of marijuana as a medical pain reducer for emotional or social pain. Further, experimental research is needed to better understand causation in the use of marijuana as a pain reducer for social pain.

**Money**

Money, one of the strongest symbols of power and happiness, can serve as a resource to facilitate social involvement or obtain one’s materialistic desires. Similar to substances that buffer social pain, research has examined whether money works as compensation to effectively reduce social and physical pain. The idea that money is a strong source of power and social status, as well as its use in attaining resources to cope with problems, suggests that acquiring money during experiences of social exclusion should reduce the level of social pain experienced (Zhou, Vohs, & Baumeister, 2009). In other words, money should buffer a painful social rejection because individuals have a more significant sense of strength and social power after acquiring it.

Research has found evidence in support of this idea. Financial compensation in a Cyberball task for social exclusion resulted in reduced negative emotions and lowered activity in the dACC compared with participants that did not receive monetary compensation (Lelieveld, Moor, Crone, Karremans, & van Beest, 2012; Zhou et al., 2009). Counting money, as opposed to paper, was also associated with less distress during exclusion and included reports of feeling stronger, suggesting that money may promote a sense of self-esteem and power in the face of rejection (Zhou et al., 2009). When financially compensated for social exclusion, participants generally experienced increased activity in the caudate nucleus, an area associated with monetary rewards (Lelieveld et al., 2012). On the other hand, thoughts of losing money by reminding individuals of past spending significantly increased negative emotions and social pain during exclusion (Zhou et al., 2009). This effect is likely because the loss of money as a social resource makes individuals dependent on the acceptance of others. These findings provide evidence that material objects linked to power and status can serve as effective compensation to reduce the immediate social pain resulting
from social exclusion because it functions as a resource to overcome rejection.

**Authentic Experiences of Social Pain**

Much of the evidence discussed so far has been gathered through laboratory studies, but how well do the findings apply to real-world social and physical pain? As laboratory evidence for a shared neural network for physical and social pain accumulates, it is important to evaluate its ecological validity. The majority of research involving the measurement of social pain incorporates social rejection through experimental manipulation, such as in Cyberball. However, such research may be limited in the extent to which it mirrors real social rejection outside of a laboratory. While experimentally-induced social exclusion is useful, its potential limitations in terms of generalizability to real-world experiences require that evidence gathered from authentic social or physical pain experiences be considered as well. For example, studies about experiences of bullying and grief may lack the control of experimental paradigms, but help provide converging evidence in support of the shared neural pain network.

**Bullying**

**Increased physiological pain.** Emotional and verbal bullying, including the contemporary form of cyber-bullying, an electronic experience of social rejection like Cyberball, is a common problem facing youth today. Compared to non-victims, victims of emotional and verbal bullying tend to report more psychosomatic symptoms, such as headaches, abdominal pain, dizziness, musculoskeletal pain, and a general increase in physical pain (Sansone & Sansone, 2008). This suggests that emotional and verbal bullying, a real experience of social rejection, is associated with increased physical pain intensity or frequency. This evidence converges with experimental work to support the theory of interrelated neural circuitry for social and physical pain systems.

**Physical pain perception later in life.** The experience of social rejection through bullying gives insight into the potential long-term effects of social rejection on pain sensitivity and frequency. Research has shown that individuals who were bullied during childhood report higher physical pain ratings at various points after childhood compared to those who did not experience bullying. They also report significantly more catastrophizing thoughts relating to the pain, including rumination, helplessness, and magnification (Sansone, Watts & Wiederman, 2013). The increased report of physical pain by adults who were bullied when they were children may either be due to an actual increase in painful stimuli or an increase in their perceived pain. The latter is more likely given the evidence suggesting the relation to bullying and pain magnification (Sansone et al., 2013). While more research concerning neurological activity and bullying is necessary to fully understand the consequences of real experiences of social rejection, these findings show preliminary support that bullying in childhood can result in a long-term heightened experience of physical pain in adulthood.

**Loss and Bereavement**

**Loss of a close relative.** Similar to social rejection, but without experimental manipulation, the loss of a loved one involves the loss of social connection. An fMRI study conducted by Gündel et al., (2003) found that when individuals are shown pictures of recently deceased first-
degree relatives (e.g., parent, sibling, child), compared to strangers, there is significantly more activity in the dACC and anterior insula. The study attributes this activity to the executive control of attention, which has been associated with the same neural regions as social pain. The attribution of this response to attention, however, can be related to the experience of social pain by the neural alarm theory with the dACC acting to detect threats of social rejection or abandonment. This explanation proposes that the lost loved one's photograph is activating an experience of social pain and offers the compelling idea that grief represents another source of social pain other than rejection. Grief related to the loss of a loved one is also commonly associated with the experience of chronic pain (Furnes & Dysvik, 2010). This documented increase in social pain and physical pain following the loss of a loved one supports the theory of interconnected social and physical pain systems.

**Loss of an unborn child.** The experience of bereavement from the loss of an unborn child is another real world occurrence of social pain, in the sense that it is a loss of future social interactions. Women who had recently lost an unborn child showed increased activity in the dACC in response to smiling baby pictures compared to other women (Kersting et al., 2009). This response supports the significance of the maternal-baby attachment and from an evolutionary perspective, underscores the development of close social connections to others for survival. The increased activity in the dACC in response to baby pictures also suggests that the grief experienced by the mother is being processed as a type of social pain within the neural pain network. This research supports the idea that there are varying sources of social pain other than social rejection.

**Importance of loss in social pain theory.** Neurologically, losing a loved one activates the same areas of the brain as social pain. This research supports the idea that grief and loss can be understood as experiences of social pain similar to the loss of social connection in ostracism. Real-world experiences of loss offer a unique perspective of social pain that experimentally-induced social pain cannot directly replicate. Understanding both experimentally-induced and real-world experiences of social pain is vital to establishing a complete understanding of how social pain works and its connection to physical pain.

**Social Rejection: Resulting in Numbing or Pain?**

Our discussion thus far has assumed that social rejection results in pain. A more nuanced analysis of the current literature reveals a more complicated story, and one that requires further study in order to understand the shared neural network between social and physical pain. While the majority of research concerning overlapping social and physical pain systems has shown an increase in social pain as a result of social exclusion, other research has contradictory findings suggesting a numbing or analgesic response to social rejection (Berstein & Claypool, 2012; Borsook & MacDonald, 2010; DeWall & Baumeister, 2006). In experiences of extreme physical damage, such as loss of a limb, the body tends to have an immediate numbing reaction with the potential purpose of allowing the individual to flee the source of danger. Perhaps, because of overlapping social and physical pain systems, numbing in response to a large social threat may act in the same manner as a severe physical injury.
Severity of social rejection. DeWall and Baumeister (2006) conducted a study using false future life predictions in which people experienced social exclusion by receiving an ostensibly accurate prediction of a negative and unsatisfactory future social life, instead of a positive future life prediction. Inclusion and exclusion through future life predictions are perceived as more intensely positive or negative than in Cyberball (Berstein & Claypool, 2012). Consistent with the idea that exclusion severity might predict the outcome of pain or numbing, Berstein and Claypool (2012) found that individuals in the severe exclusionary future-alone condition experienced the numbing effect (i.e., decreased pain sensitivity) and individuals in the less severe exclusion condition (by social rejection in Cyberball) experienced increased pain sensitivity.

The severe social exclusion results in numbing to both physical and social pain sensitivity. Specifically, individuals in the severe exclusion condition showed decreased sensitivity to and increased tolerance for physical pain and did not report significantly different emotional states than included individuals (Bernstein & Claypool, 2012). Put simply, these individuals experienced less physical pain and did not report an experience of social pain. Severely socially excluded individuals also expressed less empathy to someone who had recently experienced a relationship loss compared to someone who experienced pain from a broken leg (DeWall & Baumeister, 2006). This lack of empathy may be related to the severe social exclusion that resulted in emotional numbing and a decreased ability to relate and empathize with emotional pain.

Implications of the numbing response.

These findings show evidence of a numbing reaction to social pain and offer an alternative view of how individuals automatically cope with severe social pain. These findings, although differing from the majority of research surrounding social pain, do not undermine the evidence linking emotional pain and physical pain. In fact, the two responses to experiences of social pain suggest an even deeper connection between social and physical pain systems than previously theorized. The response to both social rejection and physical pain is dependent on the level of severity and threat, further supporting the theory of a shared neural pain system.

Limitations and Future Research

To date, research has developed strong evidence in support of a shared social and physical pain system in relation to a variety of factors. However, many questions remain concerning the connection between social and physical pain. The current body of research is limited because many studies have used the same methods of eliciting social rejection, such as with Cyberball. Future research should include a greater variation of experimentally-elicited social rejection, such as positive and negative future predictions, recalling recent romantic breakups, or instances of prejudice in regards to personal identity. Varied manipulations and attempts to validate each experimental method will potentially reveal how well each method is manipulating social rejection or whether these different methods are interfering with the conclusions drawn from studies involving social and physical pain. Using different methods for experimentally-elicited social pain may also help clarify why some experiences of social
rejection result in a pain while others result in numbing.

Further research involving fMRI technology must also explore why certain experiences of social pain, or rather why certain studies of social exclusion, do not find the same areas of brain activation relating to social pain and rejection, especially the dACC (Cacioppo et al., 2013; Karremans et al., 2011). More specifically, a meta-analysis by Cacioppo et al. (2013) failed to support the social and physical pain system overlap found by Cyberball studies and in research focused on social pain resulting from rejection by a romantic partner. The meta-analysis revealed that the dACC was not reliably activated during social exclusion in the Cyberball studies (Cacioppo et al., 2013). Only one voxel, a small portion of the brain, was activated in most studies compared to the necessary 15 in order to be significant in the meta-analysis (Cacioppo et al., 2013). While the dACC was not found to be a significant activation site for social exclusion in the meta-analysis, the anterior insula was significantly activated in most studies of rejection (Cacioppo et al., 2013). Although some research has shown support for particular areas of the brain being activated in response to social pain, the meta-analysis suggests otherwise. Researchers in opposition to the pain overlap theory suggest that social pain is figurative rather than literal (Cacioppo et al., 2013). The results of the meta-analysis suggest that the studies involving social rejection are inconsistent and fMRI studies must continue to clarify the neurological activation involved in the experience of social rejection.

As research investigates the conflicting findings from fMRI studies, future research must also determine whether this neural activity during social and physical pain (as observed in increased brain activity in areas such as the dACC and anterior insula) is indicative of brain activity relating to pain or whether it is a response to another stimulus. Other research has proposed that these neural regions are activated in regards to attention, cognitive conflict detection, rumination, and emotional craving instead of the processing of social pain (Cacioppo et al., 2013; Eisenberger, 2012b; Gündel et al., 2003; Iannetti & Mouraux, 2011). It is vital that research explores whether the studies of social pain are measuring the neural activation of pain or other salient stimuli.

Research concerning the use of substances and money to buffer social pain should continue to address whether this lowered social pain is sustained over a period time. For example, is there a limit to whether money, marijuana and acetaminophen can buffer social pain in regards to rejection intensity? Or do intense rejections, such as false future alone predictions, create a numbing experience to which the drugs and substances have no effect? While past research has not condoned use of acetaminophen or marijuana as a social pain reliever, understanding why substances and money decrease the level of social pain may help develop potential alternative therapies for individuals who are highly rejection sensitive or experience a high level of social pain. Future research should examine the use of medical marijuana as a pain reducer for social pain as past research conducted by Deckman et al. (2013) did not specify if marijuana was used medically or recreationally.

Correlational evidence drawing on real-world social rejection should continue to be included in the body of knowledge concerning the neural connectivity between physical and social pain. Converging
evidence from experimental research along with these more ecologically valid experiences will provide a clearer picture of how humans experience pain. Research should continue to explore experiences of bullying in relation to social pain. Particularly, future studies should focus on individuals currently experiencing bullying in order to understand how bullying impacts the experience of present physical pain compared to future experiences of physical pain as research has addressed in the past. Similarly, future research should continue to explore whether bereavement can be understood as an experience of social pain. Unlike other instances of social pain, the loss of a loved one does not normally involve an intention of abandonment or rejection, as bullying does. Does the lack of intention to hurt the person alter the experience of social pain compared to social rejections that involve an intention to harm? Ultimately, research must conclude whether the loss of a loved one results in social pain or if it is a separate process with traits that are similar to the experience of social pain, such as attention involved in looking at pictures of loved ones, as other researchers theorized (Gündel et al., 2003).

Finally, future research should address why people can more easily pre-live social pain than pre-live future pain through imagination. It must also determine why having increased vivid mental imagery only makes social pain pre-living, not physical pain pre-living, more intensely painful (Chen & Williams, 2012). While it has been established that imagined pain and vivid mental imagery are instances where the social and physical pain system divide, the reason for this divergence has not been studied empirically. The implications for this finding, that the two pain systems potentially do not process imagined pain in the same way, may bring forth bigger questions concerning the validity of theory of shared neural circuits. Research must continue to challenge this theory by comparing social and physical pain in different contexts to develop a greater understanding of how the systems overlap and why in certain instances social and physical pain systems differ.

Conclusion

Evidence drawn from experimental and non-experimental work analyzing social and physical pain as well as the individual differences, social factors, appraisal, and substances and objects related to the experience of pain, converge to provide a comprehensive understanding of the connection between social and physical pain. Evolutionary theory supports the theory of shared neural circuits with the explanation that including social exclusion into an existing pain response system would be adaptive because of the importance of belonging for survival. However, some research opposes the theory of shared pain systems, particularly multiple fMRI studies implicating regions of the brain involved the experience of social pain. This problem suggests the need for more research with greater variability of methods eliciting and measuring social pain to confirm that the studies are focusing on the experience of social pain.

Research involving the connections between experiences of social pain and individual differences creates a more complete understanding regarding the individualistic experiences of pain. These individual differences are associated with different level of social pain following an exclusionary experience. For example, individuals with high depression and anxiety, low trait self-esteem, greater punishment or frustration oriented system
(Behavioral Inhibition System), and high attachment anxiety are all more likely to experience a greater level of social pain following rejection or ostracism (DeWall et al., 2012; Onoda et al., 2010; Phillips & Gatchel, 2000; Yanagisawa et al., 2011b). The research involving individual differences reveals the many factors that influence the experiences of social pain and provides support for the neural connectivity between social and physical pain. Research involving current or past social support also supports the social and physical pain overlap theory because the presence of a secure attachment figure and more time spent with friends buffers social pain just like it lowers physical pain following physical stimulation (Karremans et al., 2011; Masten et al., 2012; Master et al., 2009). Likewise, substances such as acetaminophen and marijuana support the neural pain system by exhibiting similar effects of numbing both social and physical pain (Deckman et al., 2013; DeWall et al., 2010).

Continued research concerning the similar experience of social pain and physical pain may help validate the idea that social pain is just as painful, if not more aversive, than being physically harmed. Research involving real experiences of social pain and exclusion are particularly important to understand the complete relation between social and physical pain because of its greater generalizability. In application, this research can help fight stigma surrounding the belief that people are “weak” when hurt by rejection or ostracism, such as bullying or discrimination. Everyday experiences of rejection, such as instances of bias or prejudice in regards to race, gender, sexual orientation, social class, and appearance, regularly occur during social interactions and are often overlooked. The research concerning social and physical pain can form a foundation that these social rejections can be even more painful than physical abuse or attack due to bias. The growing body of empirical evidence concerning social pain and its connection to physical pain through shared neural circuitry may help establish a deeper understanding of the emotional and social pain that individuals experience as a result of different types of rejection.

References


