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Can Marijuana Reduce Social Pain?

Timothy Deckman[1], C. Nathan DeWall[1], Baldwin Way[2], Rich Gilman[3], and Stephanie Richman[1]

Abstract

Social and physical pain share common overlap at linguistic, behavioral, and neural levels. Prior research has shown that acetaminophen—an analgesic medication that acts indirectly through cannabinoid 1 receptors—reduces the social pain associated with exclusion. Yet, no work has examined if other drugs that act on similar receptors, such as marijuana, also reduce social pain. Across four methodologically diverse samples, marijuana use consistently buffered people from the negative consequences associated with loneliness and social exclusion. These effects were replicated using cross-sectional, longitudinal, and experimental designs. These findings offer novel evidence supporting common overlap between social and physical pain processes.

Keywords

depression, health, loneliness, longitudinal methodology, neuroscience, ostracism, social exclusion, well-being

When people discuss the pain of social exclusion, they often use words related to physical pain. Divorce "hurts," getting fired "stings," and being ignored by friends can make one's heart "ache." Are these simple metaphors or is there an actual link between social and physical pain? Experimental studies suggest that physical and social pain are linked in meaningful ways (Eisenberger, Lieberman, & Williams, 2003; MacDonald & Leary, 2005). Numbing the physical pain system with acetaminophen also numbs the social pain system (DeWall et al., 2010). We hypothesized that marijuana, which acts through similar receptors as acetaminophen, will numb people to social pain. Four studies showed that people who use marijuana are buffered from the negative consequences associated with social pain.

Social Pain

Humans have a fundamental need to belong (Baumeister & Leary, 1995). A lack of relationships undermines both physical and psychological health. Social pain is closely associated with, and identified by, hurt feelings (MacDonald, 2009). Pain, either physical or social, exists to alert the organism that something is wrong (Jensen-Campbell & MacDonald, 2011). As humans became more social creatures, social pain evolved to alert humans that something was amiss within their relationships. Throughout our ancestral history, social exclusion could mean death (MacDonald & Leary, 2005). Hurt feelings motivate us to fix our relationships and reestablish social connection (Jensen-Campbell & MacDonald, 2011). The physical and social pain networks have surprisingly more overlap than serving as an alert system.

Physical and Social Pain Overlap

Researchers first noticed overlap between physical and social pain systems when they discovered that opiate pain relievers alleviated separation distress vocalizations among young animals and their primary caregivers or conspecifics (Herman & Panksepp, 1978; Panksepp, Herman, Conner, Bishop, & Scott, 1978; Panksepp, Vilberg, Bean, Coy, & Kastin, 1978). These researchers theorized that evolution co-opted the social pain network directly on top of the existing physical pain network to efficiently respond to social threat. Research using functional magnetic resonance imaging has identified the anterior cingulate cortex (ACC) and periaqueductal gray as brain areas that respond similarly to both physical and social pain (MacDonald & Leary, 2005). Further work in this area suggests that social and physical pain share common overlap in regions associated with both the affective component and the sensory component of physical pain (Eisenberger et al., 2003; Kross, Berman, Mischel, Smith, & Wagner, 2011).

Given the common overlap between physical and social pain, numbing the physical pain network may help reduce social pain. DeWall et al. (2010) found that giving participants acetaminophen, a physical pain suppressant, reduced the amount of daily social pain they experienced. This study also found neural evidence of a connection between acetaminophen administration and reduced brain activity in areas associated with distress (dorsal ACC) and the emotional component of

[1] University of Kentucky, Lexington, KY, USA
[2] The Ohio State University, Columbus, OH, USA
[3] Cincinnati Children's Hospital Medical Center, University of Cincinnati Medical School, Cincinnati, OH, USA

Corresponding Author:
Timothy Deckman, University of Kentucky, 0004 Kastle Hall, Lexington, KY 40506, USA.
Email: timdeckman@gmail.com

physical pain (anterior insula) following social rejection. These results show a relationship between the physical and social pain networks at both behavioral and neural levels. They also demonstrate that numbing the physical pain network with a common, over-the-counter analgesic can also numb the social pain network.

Even though acetaminophen is a widely used pain reliever, it was not until recently that evidence uncovered a potential molecular mechanism for its analgesic action. Understanding acetaminophen's mechanism of action may help identify other drugs that aid in reducing social pain.

Acetaminophen's Mechanism of Action

The cannabinoid 1 (CB_1) receptor is critical for the analgesic effects of acetaminophen. CB_1 receptor knockout mice show no analgesic response to acetaminophen (Mallett et al., 2008). Likewise, antagonists of the CB_1 receptor block the analgesic effect of acetaminophen in both mice (Mallett et al., 2008) and rats (Ottani, Leone, Sandrini, Ferrari, & Bertolini, 2006). These effects carry over to other emotional behaviors because CB_1 antagonists also block the anxiolytic effects of acetaminophen in mice (Umathe, Manna, Utturwar, & Jain, 2009).

These rodent data suggest that the CB_1 receptor modulates affective states, which is supported by postmortem research in humans. Depressed suicide victims showed an upregulation of CB_1 receptors in the prefrontal cortex (Hungund et al., 2004), presumably reflecting compensation for reduced endogenous CB levels. Consistent with this interpretation, both the U.S. Food and Drug Administration and the European Medication Agency recalled the CB_1 antagonist rimonobant due to its proclivity to increase depressive symptoms by preventing signaling through the CB_1 receptor (Hill & Gorzalka, 2009). This research indicates that CB_1 receptor activation is a likely mechanism by which acetaminophen buffered people from social pain. Examining the effects of another drug that acts through CB_1 receptors and examining whether it also buffers people from social pain would provide corroborative evidence of this mechanism for acetaminophen's action.

Marijuana, Physical Pain, and Social Pain

One well-documented agonist of the CB_1 receptor is Δ^9—tetrahydrohydrocannabinol (THC; Matsuda, Lolait, Brownstein, Young, & Bonner, 1990), the major psychoactive ingredient in marijuana. Marijuana, much like acetaminophen, relieves physical pain. In clinical trials, marijuana relieved neuropathic pain (Ellis et al., 2009; Wilsey, Marcotte, Tsodikov, & Milman, 2008) and pain in response to a capsaicin (the active chemical in hot peppers) injection (Wallace et al., 2007). Acetaminophen and marijuana both affect CB_1 receptor-mediated signaling. Thus far, we have noted that social pain and physical pain share a similar underlying network, that numbing one pain network can also numb the other network, and that both acetaminophen and marijuana dampen physical pain.

The question arises as to whether an agonist of the CB_1 receptor would decrease consequences associated with social pain. Research showing that cannabis administration reduces amygdala reactivity in response to socially threatening images (Phan et al., 2008) points to a potential relationship between THC and affect. What remains unclear, however, is whether marijuana can reduce the consequences of social pain.

Many negative consequences of social exclusion exist, such as higher depression, lower self-esteem (Leary, 1990), and decreased psychological health (DeLongis, Folkman, & Lazarus, 1988). Could another pain reliever buffer people from these negative consequences of social pain as well?

Because marijuana acts through the same CB_1 receptors as acetaminophen, we predict that it will also buffer users from the negative consequences of social pain. Therefore, we used the following outcome measures to test our hypothesis: self-esteem, self-reported mental health status, diagnosis of a *Diagnostic and Statistical manual of Mental Disorders, Fourth Edition* (DSM-IV) major depressive episode in the past year, levels of depressive symptoms, and threatened needs. If marijuana use buffers those who are experiencing social pain from these negative outcomes, it will support our hypothesis.

The Present Studies

We predicted that marijuana use would buffer people from the negative consequences of social exclusion. To test this hypothesis, we conducted four methodologically diverse studies. In each study, participants reported their frequency of marijuana use. Next, participants reported their level of loneliness, a proxy for social pain (Studies 1–3), or were exposed to an experimental manipulation of social exclusion (Study 4). Finally, participants completed a measure of their psychological well-being. We predicted that elevated levels of marijuana use would attenuate the relationship between feelings of social exclusion and poor psychological well-being.

Study 1: Marijuana Use Buffers Lonely People From Lower Self-Worth and Self-Rated Mental Health

In Study 1, we tested if marijuana use moderated the relationship between social pain and self-rated mental health. Using a nationally representative sample of adults, we used loneliness as a proxy for social pain and self-rated self-worth and perceived mental health status as indicators of psychological well-being.

Method

Participants

This study used data from the National Comorbidity Study: Baseline (NCS-B; Kessler, 1990–1992), which is a nationally representative sample from the continental United States. This study recruited 8,098 participants, of which 5,877 completed a follow-up risk assessment interview that included drug use

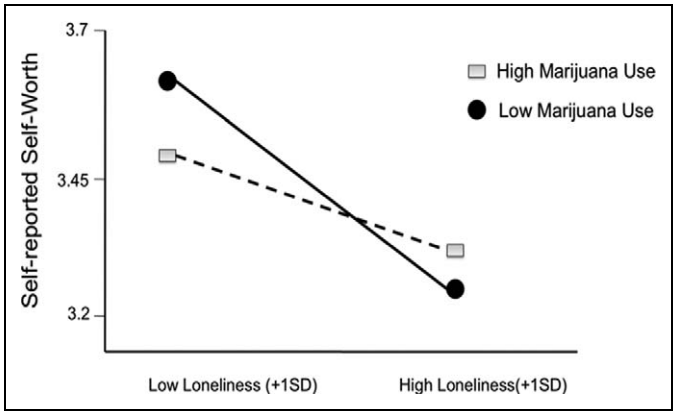

Figure 1. Study 1: Marijuana use moderates the relationship between loneliness and self-reported feelings of self-worth.

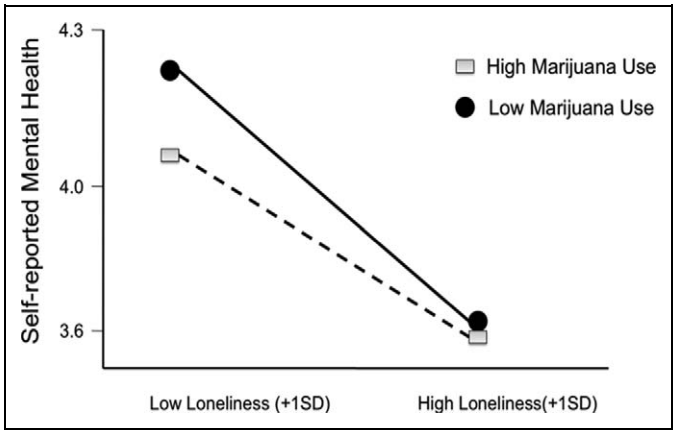

Figure 2. Study 1: Marijuana use moderates the relationship between loneliness and self-reported mental health.

questions. A final sample of 5,631 (2,934 females and 2,697 males) participants had data points for loneliness, marijuana use, and both self-rated self-worth and mental health. A sampling weight was used to account for differences in probability sampling because data from the risk assessment interview was used. Participants ranged in age from 15 to 54 ($M = 32.1$, $SD = 10.6$). The racial breakdown of the sample was as follows: 82.1% White, 11.6% African American, 3.3% American Indian, 1.7% Asian, and 1.3% Other.

Materials and Procedures

The NCS-B had a single self-report item assessing loneliness, which was used as a proxy for social pain. Loneliness is the result of thwarting of a person's need to belong. Not surprisingly, loneliness and deficits in belongingness share many negative consequences including impairments to both physical and mental health (for a review, see Baumeister & Leary, 1995; Cacioppo & Patrick, 2008). Participants were asked how lonely they felt on average over the past 30 days using a Likert-type scale (1 = *often*, 4 = *never*; reverse-scored; $M = 1.80$, $SD = 0.98$). Marijuana use was also assessed with a single, Likert-type scale, self-report item. The question asked how often on average participants used marijuana over the past 12 months (0 = *not at all*, 1 = *1 or 2 days over the past 12 months,* 8 = *daily*; reverse-scored; $M = 0.53$, $SD = 1.65$). Both loneliness and marijuana use were standardized prior to analysis ($M = 0$, $SD = 1$).

We investigated two outcome measures for this study, namely feelings of self-worth and self-rated mental health. Participants answered a single item on feelings of self-worth (*I am a person of worth, at least equal of others*) on a 4-point rating scale (1 = *very true*, 4 = *not at all true;* reverse-scored; $M = 3.43$, $SD = 0.82$). Participants also responded to a single question asking them to self-report their own mental health relative to others (1 = *excellent*, 5 = *poor*; reverse-scored; $M = 3.86$, $SD = 0.94$).

Results

Weighted least squares regression was used to examine the impact of loneliness, marijuana use, and their interaction on both self-rated self-worth and mental health. Loneliness and marijuana use interacted to predict feelings of self-worth, $B = 0.03$, $t(5609) = 2.20$, $p = .03$ (see Figure 1). A follow-up simple effect test showed that the negative relationship between loneliness and lower feelings of self-worth and self-rated mental health was stronger among participants who smoked marijuana relatively infrequently (-1 *SD*): $B = -0.20$, $t(5609) = -12.29$, $p < .001$, compared to participants who smoked marijuana relatively frequently ($+1$ *SD*).

A similar loneliness by marijuana use interaction emerged for self-rated mental health relative to others, $B = 0.03$, $t(5609) = 2.07$, $p = .04$ (see Figure 2). Compared to participants who smoked marijuana relatively infrequently, $B = -0.31$, $t(5609) = -17.18$, $p < .001$, those who smoked relatively frequently showed a weaker negative association between loneliness and self-rated mental health, $B = -0.26$, $t(5609) = -14.96$, $p < .001$. Tables 1 and 2 list the main effects of both marijuana use and loneliness across all four studies.

Discussion

Study 1 used a nationally representative sample to examine the moderating relationship of marijuana use between social pain and psychological well-being. Marijuana use buffered the lonely from both negative self-worth and poor mental health. This evidence suggests that at relatively high levels of social pain, marijuana use lessens negative consequences of social pain.

This study contained some limitations. First, it only assessed self-ratings of both self-worth and mental health. If marijuana use weakens the relationship between social pain and self-reported psychological well-being, then there should also be a lower rate of validated clinical diagnoses of poor psychological well-being.

Study 2: Marijuana Use Predicts Fewer Major Depressive Episodes Among the Lonely

To address the limitation of Study 1, Study 2 sought to show that marijuana buffered lonely participants from experiencing

Table 1. Main Effects of Marijuana Use on Dependent Measures Across Four Studies.

Dependent Variable	Unstandardized Coefficient	*t*	*p*
Mental health	−0.05	−3.86	<.001
Self-rated self-esteem	−0.01	−1.24	.21
DSM major depressive event (past year)	0.23	—	.06
Depression (1 year later)	−0.04	−1.54	.13
Need threat	0.10	1.20	.20

Note. DSM = *Diagnostic and Statistical manual of Mental Disorders.*

Table 2. Main effects of Loneliness on Dependent Measures Across Four Studies.

Dependent Variable	Unstandardized Coefficient	*t*	*p*
Mental health	−0.28	−21.44	<.001
Self-rated self-esteem	−0.17	−14.34	<.001
DSM major depressive event (past year)	0.67	—	<.001
Depression (1 year later)	0.01	0.38	.70
Need threat	−1.35	−22.97	<.001

Note. DSM = *Diagnostic and Statistical manual of Mental Disorders.*

a standardized diagnosis of poor psychological well-being. Study 2 used a different nationally representative sample from Study 1 to test this hypothesis.

Method

Participants

Study 2 employed data from the National Comorbidity Survey Replication (NCS-R; Kessler & Merikangas, 2004). Participants were aged 18 years and older and were residents of the continental United States. The NCS-R also consisted of two parts. Part I consisted of a core diagnostic assessment and was administered to all respondents ($N = 9{,}282$). Part II of the NSC-R was a follow-up questionnaire asking participants risk factors, drug use, and other disorders ($N = 5{,}692$). Our final sample included 537 participants (187 females, 350 males) who reported loneliness, marijuana use, and if they had experienced a DSM-IV major depressive episode during the past year. The average age of participants in the sample was 30.5 ($SD = 11.0$). Demographically participants were 68.4% White, 14.0% African American, 12.6% Hispanic, 1.9% Asian, and 3.1% Other.

Materials and Procedures

As in Study 1, participants reported their level of loneliness over the past 30 days using a Likert-type scale (1 = *often*, 4 = *never*; reverse-scored; $M = 2.08$, $SD = 1.13$). Participants also reported their marijuana use over the year on a Likert-type scale (1 = *nearly every day*, 5 = *less than once a month*; reverse-scored; $M = 2.45$, $SD = 1.53$). Again, both loneliness and marijuana use were standardized prior to analysis ($M = 0$, $SD = 1$). Participants then reported whether they had been diagnosed with a DSM-IV major depressive episode during the past year ($M = 0.18$, $SD = 0.38$).

Results

Binary logistic regression was used to determine whether marijuana use moderated the relationship between loneliness and experiencing a DSM-IV major depressive episode during the past year. Loneliness and marijuana use interacted to predict whether participants experienced a major depressive episode over the past year $B = -0.20$, $p = .02$ (see Figure 3). This

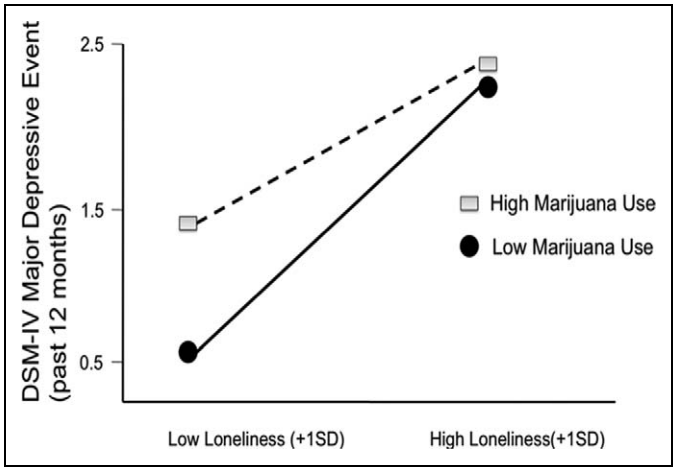

Figure 3. Study 2: Marijuana use moderates the relationship between loneliness and a having a DSM-IV major depressive event in the past 12 months. DSM-IV = *Diagnostic and Statistical manual of Mental Disorders,* fourth edition.

interaction was next probed using a statistical macro designed specifically for interactions within logistic regression (Hayes & Matthes, 2009). Consistent with Study 1, the relationship between loneliness and the probability of experiencing a major depressive episode over the past year was stronger among participants who smoked marijuana relatively infrequently (−1 *SD*), $B = 0.86$, $Z = 6.47$, $p < .0001$ compared to participants who smoked marijuana relatively frequently (+1 *SD*), $B = 0.46$, $Z = 4.05$, $p = .0001$.

Discussion

Study 2 demonstrated that marijuana use buffers people from more than just self-reports of poor psychological well-being associated with social pain. Those who were experiencing social pain and who used marijuana relatively frequently were less likely to experience a DSM-IV major depressive event during the past 12 months. This finding ruled out the possibility that marijuana use merely skewed people's cognitive functioning and thus, their own mental well-being. Rather, marijuana use buffered those who were lonely from experiencing a DSM-IV major depressive episode. This result also suggests

that the buffering effect of marijuana on social pain is found in objective third-party assessments as well as self-reports.

One potential limitation of Studies 1 and 2 is that they both use cross-sectional designs. To address this limitation, Study 3 used longitudinal data to examine whether marijuana use buffers people from negative consequences of social pain in the future.

Study 3: Marijuana Use Predicts Less Depression Among the Lonely Over Time

Study 3 used a longitudinal design to examine whether marijuana buffered lonely people from experiencing elevated depressive symptoms 2 years later. Using a longitudinal design added statistical rigor because baseline levels of depression can be controlled for when predicting future levels of depression.

There is an additional benefit to using a longitudinal design in Study 3. In Studies 1 and 2, we ran contrasts testing to see if those who use marijuana relatively frequently were less affected by loneliness than those who do not use marijuana at all or somewhat infrequently. However, it is possible that marijuana use differentiates people on baseline measures of well-being, making a comparison between the groups inappropriate. To address this limitation, Study 3 used a baseline measure of well-being (depression) in order to control for potential differences between groups and get a cleaner look at the effect of marijuana use on the negative consequences of loneliness. If our hypothesis is true, marijuana use should have an impact on well-being among those who are relatively lonely, but marijuana use should have little or no impact among those who are not relatively lonely.

Method

Participants

The sample consisted of 401 high school students (248 females, 153 males) from a Southeastern state. The average age of students at Time 1 was 15.7 ($SD = 0.55$). The racial breakdown of participants was as follows: 82.3% White, 8.7% African American, 4.0% Asian, 1.7% Hispanic, and 3.2% Other.

Materials and Procedure

Participants reported loneliness, lifetime marijuana use, and depression. Two years later participants again reported their level of depression. Loneliness was assessed by asking participants, ''compared to your friends how accepted by others in your school do you feel?'' on a 4-point Likert-type scale (0 = *never*, 3 = *always*; reverse-scored; $M = 0.58$, $SD = 0.81$). Respondents completed a single item on the Youth Risk Behavior Survey-High School (Center for Disease Control and Prevention, 2009) asking them to list their frequency of lifetime marijuana use on a 6-point Likert-type scale (1 = *never*, 6 = *20 or more times*; $M = 1.38$, $SD = 1.09$). Depression was measured at Times 1 and 2 using the *Behavior Assessment System for Children,* second edition (Reynolds & Kamphaus, 2004), a common clinical instrument to measure psychological distress in school-aged youth. Respondents rated 12 items on a 4-point Likert-type scale (0 = *never*, 3 = *almost always*; Time 1 $M = 0.47$, $SD = 0.53$, $\alpha = .89$; Time 2 $M = 0.39$, $SD = 0.48$, $\alpha = .90$), with higher domain scores reflecting higher levels of depression. The completion rate between each time point was 84%.

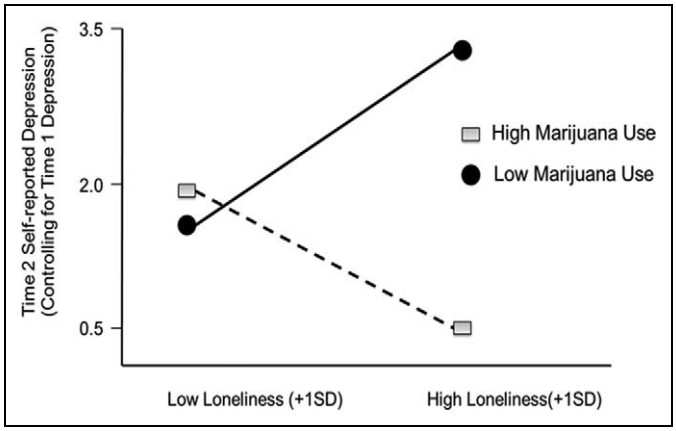

Figure 4. Study 3: Marijuana use moderates the relationship between loneliness and depression over 2 years in adolescents.

Results

To test whether marijuana buffers lonely individuals from depression 2 years later, we used multilevel regression. Loneliness and marijuana use interacted to predict depression 2 years later, controlling for baseline levels of depression, $B = -0.08$, $t(396) = -3.02$, $p = .003$ (see Figure 4). Consistent with Studies 1 and 2, the relationship between loneliness and later depression was stronger among participants who smoked marijuana relatively infrequently (-1 *SD*), $B = 0.09$, $t(396) = 2.15$, $p = .03$ compared to participants who smoked marijuana relatively frequently ($+1$ *SD*), $B = -0.07$, $t(396) = -1.45$, $p = .15$.

We also tested the impact of marijuana use among those who were relatively not lonely (-1 *SD*) and those who were relatively lonely ($+1$ *SD*). Among those who were relatively not lonely, marijuana had little impact on depression 2 years later, $B = 0.018$, $t(396) = 0.40$, $p = .69$. However, among those who were relatively lonely, marijuana use did make a difference, $B = -0.10$, $t(396) = 2.27$, $p = .02$, such that those who used marijuana relatively frequently ($+1$ *SD*) reported lower levels of depression than those who used marijuana relatively infrequently (-1 *SD*).

Discussion

Study 3 added convergent validity to Studies 1 and 2 by showing that marijuana buffers people from the negative consequences of social pain 2 years later. This study extends Studies 1 and 2 because it also controls for baseline levels of depression when examining the impact of loneliness and

marijuana use on later levels of depression. Consistent with our hypothesis, marijuana use only predict lower levels of later depression among participants who were lonely. One limitation of the previous three studies is that they lacked experimental control. To address this limitation, we conducted Study 4.

Study 4: Marijuana Use Predicts More Perceived Acceptance Following Social Exclusion

Our final study used an experimental manipulation of social exclusion to examine whether marijuana use attenuates the causal link between social exclusion and threatened needs. Using an experimental design allowed us to administer a standardized exclusion experience. We were also able to randomly assign who experienced exclusion, controlling for any preexisting relationship between loneliness and marijuana use that might exist in our previous studies.

Method

Participants

A total of 225 (130 females and 95 males) participants were recruited from Amazon's Mechanical Turk for this study. They had an average age of 32.3 years ($SD = 12.3$). Participants received $1.00 USD for their participation. Demographically, participants were 80.9% White, 7.1% Asian, 4.0% African American, 3.1% Multiracial, 0.4% American Indian, and 4.4% Other.

Materials and Procedure

Participants first responded to the question, "how often in the past 12 months have you smoked marijuana or hashish?" on a 9-point Likert-type scale (0 = *not at all,* 8 = *daily*; reverse-scored; $M = 0.98$, $SD = 2.21$). Next, participants played an ostensible ball-tossing game. In this 40-trial three-player game, participants threw the ball to whichever of the two players they choose. In reality, this was a preprogrammed social exclusion manipulation, called *Cyberball*, that randomly excluded one half of participants (Williams, Cheung, & Choi, 2000). Participants in the exclusion condition received the ball once from each of the other two players and for the remainder of the time did not receive the ball again. Participants in the control condition received the ball an equal number of times as the other two players.

After playing Cyberball, participants filled out the need-threat scale (Williams, 2009). The need-threat scale is a 20-item scale that assesses threatened needs of self-esteem, belonging, meaningful existence, and control. Participants rated the degree to which they agreed with a series of statements from 1 (*do not agree*) to 7 (*agree*). Sample items from this scale included, "I felt as one with the other players" and "I had the feeling that the other players did not like me" (reverse-scored). These items were averaged with higher values indicating higher amounts of threatened needs ($M = 3.76$, $SD = 1.59$, $\alpha = .96$).

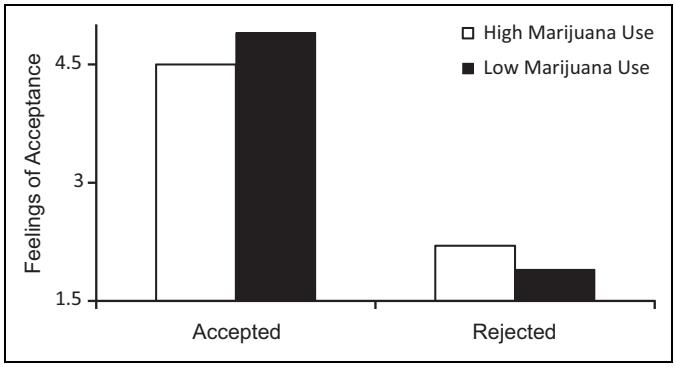

Figure 5. Study 4: Marijuana use moderates the relationship between social exclusion and feelings of acceptance.

Results

Social exclusion and marijuana use interacted to predict threatened needs, $B = 0.25$, $t(221) = 2.25$, $p = .03$ (see Figure 5). The relationship between social exclusion (vs. social acceptance) and lower threatened needs was weaker among participants who smoked marijuana relatively infrequently (-1 *SD*), $B = -2.97$, $t(221) = -15.65$, $p < .001$, compared to participants who smoked marijuana relatively frequently ($+1$ *SD*), $B = -2.48$, $t(221) = -19.59$, $p < .001$.

Discussion

Study 4 showed that marijuana use decreased amounts of threatened needs following an experimentally manipulated social exclusion task. This study extends the previous studies by showing that the causal relationship between social exclusion and distress depends on how often participants smoked marijuana.

General Discussion

These findings offer novel evidence regarding the overlap between social and physical pain processes. Prior work has shown that the analgesic acetaminophen, which acts indirectly through CB_1 receptors, reduces the pain of social exclusion. The current research provides the first evidence that marijuana also dampens the negative emotional consequences of social exclusion on negative emotional outcomes. These studies build upon research about social and physical pain overlap by suggesting that CB_1 receptor activation, via either acetaminophen or marijuana, buffers people from social pain.

Our findings do not advocate for widespread use of marijuana to treat all forms of emotional pain. Although socially disconnected individuals may smoke marijuana as a self-medication for the adverse effects of their social situation, there are likely more efficacious therapies that are not associated with the health risks (Moore et al., 2007) of regularly smoking marijuana.

Prior work has shown conflicting results with the relationship between marijuana use and depression, potentially due

to insufficient attention to possible moderating variables. One such moderating variable is whether marijuana use is medical or recreational, with medical use predicting higher levels of depression (Denson & Earleywine, 2006). Although medical marijuana use has increased in recent years, it is dwarfed by the number of recreational marijuana users (O'Connell & Bou-Matar, 2007; Substance Abuse and Mental Health Services Administration, 2010). The current investigation used samples of participants who are likely to use marijuana for recreational use, such as nationally representative samples of Americans, high school students, and visitors to an online research site. Because none of the current samples included measures to account for whether participants used marijuana for medical or recreational use, it is an open question as to whether medical marijuana use would buffer people from the negative emotional consequences of social exclusion.

Alternative Hypotheses

Several alternative hypotheses exist that warrant consideration. First, marijuana use may limit the range of a person's positive or negative emotional responding. After reexamining our data from Study 1, marijuana use correlated negatively with self-ratings of being lively, outgoing, and temperamental ($r = -.05$, $p = .001$; $r = -.03$, $p = .02$; $r = -.06$, $p < .001$, respectively), which might lead one to think that marijuana users are less emotionally responsive. However, marijuana use was also positively correlated with self-ratings of being irritable ($r = .05$, $p < .001$) and envious ($r = .06$, $p < .001$). So in some instance people are less emotionally responsive, but in other cases they are not. It is outside the scope of this project to fully address whether marijuana use makes people less emotionally responsive. What we did find was that marijuana use does buffer people (perhaps by making them less emotionally responsive) from the negative consequences normally associated with social pain.

Second, we ignored the role of individual differences that covary with marijuana use. As noted above, marijuana use was significantly negatively associated with self-ratings on measures of being lively, outgoing, and temperamental and significantly positively associated with self-ratings on measures of being irritable and envious. As these variables are all significantly associated with marijuana use, we reran our analyses from Study 1 (where we had self-report data on these attributes) to see if the interaction between loneliness and marijuana use remained significant when we entered the interaction term of each self-rating and marijuana use independently as covariates (Yzerbyt, Muller, & Judd, 2004). Table 3 shows that while there are many individual differences that are associated with marijuana use in Study 1, the interactions that we present remain significant 8 of the 10 times when controlling for individual differences. Both interactions that are no longer significant after entering individual difference covariates remain marginally significant. The results of these analyses indicate that the interaction between marijuana use and loneliness remains even when controlling for individual differences that are associated with marijuana use.

Table 3. Significance Values of Loneliness × Marijuana When Covarying Individual Difference Measures.

Individual Difference Measure	Self-Rated Self-Esteem	Self-Rated Mental Health
Outgoing	.02	.03
Lively	.02	.04
Temperamental	.04	.07
Irritable	.01	.05
Envious	.02	.10

Much has already been written about the individual differences that make people at risk for marijuana use. Instead of focusing on the individual differences that make people at risk for marijuana use, we attempt rather to frame this project using marijuana use as a predictor variable. Whether marijuana use buffers people from negative consequences depends on the individual's level of loneliness (social pain).

It is possible that loneliness and marijuana use are related to each other in a consistent and meaningful way and that this is the cause of the results we present. In Studies 1 and 2, marijuana use was significantly associated with loneliness (Study 1 $r = .06$, $p < .001$; Study 2 $r = .11$, $p = .01$). However, marijuana use was not significantly associated with loneliness in Study 3 ($r = .02$, $p = .20$). This correlation could not be calculated for Study 4, as participants were randomly assigned to their exclusion condition.

This is a difficult question to answer based on a correlational link between marijuana use and loneliness. Marijuana users might report less loneliness due to CB_1 receptor activation which buffers people from experiencing social pain. However, causality cannot be established in a correlational relationship. The reverse may also be true; people may use marijuana more frequently to cope with the social pain associated with loneliness.

Limitations and Future Directions

One limitation of the above studies is that we did not directly manipulate marijuana use. However, it is unclear whether an acute dose of marijuana would have the same impact on social pain as chronic use. In the study by DeWall et al. (2010), which administered acetaminophen to participants daily, there was not a significant decrease in daily social pain until after 2 weeks. Future research may examine whether an acute dose of marijuana would produce similar results.

Another potential limitation to some of the above studies lies in how social pain was measured. In Studies 1–3, single-item measures of loneliness were used as a proxy for social pain. These studies use large community sample data sets and thus our ability to include numerous measures was limited. However, future research may address this limitation using the 3-item Loneliness scale (Hughes, Waite, Hawkley, &

Cacioppo, 2004). This measure may yield a more reliable measure of loneliness, and thus social pain, than our single-item measure.

Conclusion

The implication is that drugs that reduce physical pain can also reduce emotional pain. Opiate-based medications (such as morphine or codeine), which are thought of primarily as ''painkillers,'' also alleviate emotional pain (Herman & Panksepp, 1978; Kalin, Shelton, & Barksdale, 1988; Panksepp et al., 1978; Panksepp, 1998). Likewise, antidepressants, which are typically prescribed to treat anxiety and depression (often related to social stressors) are also effective in alleviating physical pain (Nemoto et al., 2003; Shimodozono, Kawahira, K., Kamishita, Ogata, & Shin-Ichi, 2002; Singh, Jain, & Kulkami, 2001) and are now commonly prescribed to treat chronic pain conditions. Marijuana has been used to treat physical pain (Martín-Sánchez, Furkawa, Taylor, & Martin, 2009; Wilsey et al., 2008), and the current findings suggest that it may also reduce emotional pain. This may reflect a poor way of coping with social pain, but it may also explain some of the widespread appeal of marijuana.

Declaration of Conflicting Interests

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Author Biographies

Timothy Deckman is a recent graduate of the social psychology graduate program at the University of Kentucky. His thesis was titled, "SELF-CONTROL AS A CONTATION: Self-Control Bolstering Within a Social Network." While at the University of Kentucky, his research focused on self-control, but also included work on social exclusion and aggression.

C. Nathan DeWall has been working as a professor at the University of Kentucky since 2007. His main line of research is on social exclusion and acceptance. He has also made research contribution to the fields of self-control/depletion and aggression.

Baldwin Way recently completed his postdoctorate training at UCLA and is now a faculty member at The Ohio State University. His research takes a multipronged approach acceptance and rejection. His research looks at specific chemical, neural, and psychological pathways by which social relationships impact indices of health and health outcomes.

Rich Gilman is the director of psychology in the Division of Developmental and Behavioral Pediatrics. He is a licensed psychologist in Kentucky and Georgia, and specializes in working with children, adolescents, and their families who experience a variety of emotional/behavioral difficulties. He has authored over 50 peer-reviewed publications and book chapters, has recently coedited a book on positive youth development, and has presented his findings to numerous international, national, and regional conferences.

Stephanie Richman is in the social psychology PhD program at the University of Kentucky. She recently defended her master's thesis on self-concept clarity. She received her undergraduate degree from Northwestern University.