Observer influences on pain: an experimental series examining same-sex and opposite-sex friends, strangers, and romantic partners

Rhiannon Edwards[a,b], Christopher Eccleston[b], Edmund Keogh[a,b] *

[a] Department of Psychology, University of Bath, UK.

[b] Centre for Pain Research, University of Bath, UK.

*Corresponding author:

Rhiannon Edwards

Centre for Pain Research,

University of Bath,

Bath, BA2 7AY,

United Kingdom

Email: R.T.Edwards@bath.ac.uk

Tel: +44 (0) 1225 38 5449

Running head: Observer influences on pain

Number of pages: 39

Number of figures/tables: 8

Key words: social communication, pain, interpersonal relationships, dyads

Abstract

Despite well documented sex and gender differences, little is known about the relative impact of male-female social interactions on pain. Three experiments were conducted to investigate whether the type of interpersonal relationship men and women have with an observer affects how they respond to experimental pain. Study 1 recruited friends and strangers, Study 2 examined the effects of same and opposite-sex friends, whereas Study 3 investigated the differences between opposite-sex friends and opposite-sex romantic partners. 144 dyads were recruited (48 in each study). One person from each dyad completed two pain tasks, while the other person observed in silence. Overall, the presence of another person resulted in an increase in pain threshold and tolerance on the cold pressor task and algometer. The sex status of the dyads also had a role, but only within the friendship groups. In particular, male friends had the most pronounced effect on men's pain, increasing pain tolerance. We suggest that the presence of an observer, their sex, and the nature of the participant-observer relationship all influence how pain is reported. Further research should focus on dyadic relationships, and their influence on how men and women report and communicate pain in specific contexts.

1. Introduction

Sex and gender differences exist in pain [1; 18]. While progress has been made in our understanding of the biological and psychological mechanisms, less is known about social-contextual factors [25]. This absence is surprising given that interpersonal factors play a role in pain [14], and that reduced social support and increased social isolation are problematic [6]. One way to improve our understanding of social factors is to turn to models that consider the wider context in which pain occurs [14]. These acknowledge that pain does not occur in isolation, but can also be considered a social exchange between individuals. By applying a sex and gender focus to dyadic interactions, we can start to view such exchanges as a mixture of same and opposite-sex situations [25].

Both experimental and clinical pain research also highlights that the relationship people have with one another is important [8; 9; 44]. For example, in experimental pain research, pain and its expression can differ depending on whether the person is accompanied by a partner, family member or stranger [10; 38; 46]. However, few experimental studies look at the interaction between participant-observer sex and the nature of relationships, e.g., friend or stranger [12]. A further limitation is that the range of possible social relationships investigated is small. Most investigators examine the role of family members (spouse, parent etc.) compared to strangers, whereas individuals typically experience a wider range of interpersonal exchanges, including work-colleagues, friends, strangers, and enemies. Surprisingly, to our knowledge, there are no studies that consider the role that friendship may have for pain, despite non-romantic friendships playing an important role in social support networks [4], and how friends may buffer against isolation in later life. Few studies, if any, consider the sex of friends in the context of pain.

The aim of the current investigation was to extend previous research into the role that dyadic social relationships have on pain by considering the type of relationship between individuals in the context of sex differences. Although we considered different types of dyadic relationship, a particular focus was placed on the role friendship has on reporting pain. Three studies are reported, all using the same experimental pain induction paradigm and methods. Study 1 compares the effect of having a friend or a stranger present, Study 2 focuses on whether the sex of the friend plays a role, and Study 3 compares the difference between opposite-sex friends and opposite-sex romantic partners on pain. We hypothesise that in all studies: 1. participants will report less pain when an observer is present rather than alone; 2. women will report more pain than men; and 3. the closer the relationship within dyads the greater the pain reducing effect: so those accompanied by a friend will report less pain than when with a stranger, and those accompanied by a romantic partner's condition will report the least pain of all.

2. Study 1: Friends vs. Strangers

2.1. Method

2.1.1. Design

A mixed-groups design was employed. There were two between-groups factors: sex of the participant (male vs. female), and the relationship between the participant and their observer (friend vs. stranger). The within-groups variable was the phase of testing (observer present vs. observer absent). The dependant variables were the various pain response indices from the pain induction tasks.

2.1.2. Participants and observers

Based on a power analysis for medium effect sizes, a total of 96 adults (47 male, 49 female; M = 24.69 years, SD = 6.51 years) were recruited from the University of Bath via an undergraduate research participation scheme, posters, emails and word-of-mouth. Given a similar design was used across the three studies, 96 participants were recruited separately for each study, using the same methods. The precise method of recruitment depended on which group participants were initially allocated to (see below). Condition order was determined at the very start of each study using the random list function in Microsoft Excel. As participants were recruited they were allocated to the next available condition on this randomised list, and informed which type of dyadic partner they would be required to bring. None of the participants reported taking medication, and they all reported being pain-free. To reduce the likelihood of participants experiencing adverse effects from the pain induction task, participants were excluded if they had eczema, asthma and/or sensitive skin.

Participants were recruited to take part in a pain study, where they were asked to either experience pain or observe someone in pain. A total of 48 participants were allocated into the pain experience condition. A further 24 participants were recruited into the stranger-observer condition. Of these, there were 11 same-sex stranger dyads and 13 opposite-sex stranger dyads. An additional 24 participants were recruited as friend-observers. Given the need for the observers to have a pre-existing relationship with the person in pain, a different method of requirement was required. Here, the 24 participants who had been allocated to the pain experience condition with a friend, were asked to identify a friend of their choice, who was not a romantic partner. Interestingly, all participants brought a friend of the same-sex with them to the study. Therefore, in total, 11 same-sex strangers, 13 opposite-sex strangers, and 24 same-sex friends were recruited into the study. This method of recruitment resulted in 48 dyads being created, each of which consisted of 48 participants in the pain experience condition (24 male; M = 26.62 years, SD = 8.14 years and 24 female; M = 22.75 years, SD = 3.54 years) and 48 observers (23 male; M = 27.04 years SD = 3.75 years, and 25 female; M = 22.72 years SD = 3.57 years). Within the dyads, half consisted of stranger observers and half consisted of friends of the person to experience pain.

2.1.3. Pain induction tasks

A cold pressor task was adopted to induce pain, which is considered a safe and valid method of pain induction [47]. This pain induction task has also been used in previous social dyadic pain studies [45]. Participants submerged their left hand in a water bath at room temperature for 2 minutes to standardise their hand temperature [43]. Next, participants submerged the same hand in a cold water bath, which was kept at a constant temperature of 1 °C (± 1°C) [36]. Water temperature was maintained by a Techne thermoregulator and a dip cooler (Model: RU-200), and the water circulated to prevent local warming around the participant's hand, to ensure consistency across the study [35]. During the cold water exposure, participants were timed from immersion to when they first experienced a painful sensation (pain threshold), and to the point at which they could no longer tolerate the pain (pain tolerance). Unknown to the participants, there was an upper limit of two minutes, at which point the experimenter asked the participant to withdraw their hand [26].

A pressure pain induction task was also included in order to determine whether effects would generalise across different types of pain. Pressure pain was induced using a hand-held Somedic Algometer [11]. The algometer comprises of $1cm^2$ round rubber surface which comes in contact with soft tissue [28] on the right forearm, at a rate of 30 kPa/sec. Pressure was applied in a similar place on the dorsal forearm, approximately 8cm from the elbow [22]. Participants were asked to indicate the first point at which they felt a painful sensation, and this was recorded as their pressure pain threshold. A total of three trials were conducted, with a short interval between trials, to increase reliability. An average of the three trials was taken.

2.1.4. Self-report measures[1]

The following self-report measures were administered to those in the pain condition:

[1] All participants also completed the Gender Role Expectations of Pain measure as part of a larger PhD project. Since this is not relevant to the current analysis, it was not included here.

A Visual Analogue Scale (VAS) was administered after each pain induction, in order to measure how much pain was subjectively experienced during the task. Participants were asked to mark their answer on a 100mm line, with anchors indicating the range: from *no pain at all* (0) to *worst pain imaginable* (100). VAS scales are used widely in pain research, and have high levels of validity for both chronic and experimental pain induction tasks [38].

The Short Form McGill Pain Questionnaire (SF-MPQ-2) was administered after each pain induction. The questionnaire consists of 22 pain-related symptoms that each participant rated on a Likert-scale based on the intensity of the pain, ranging from 0 *(no pain)* to 10 *(worst possible pain)* [16]. The overall total score was calculated (internal consistency: α = .91 [16]) for the current study, with a higher number indicating more pain. The SF-MPQ-2 has been used in both experimental pain induction studies and with chronic pain patients. This scale is also reported to be both valid and reliable [21].

In addition, all participants (pain and observer condition) completed various scales after the pain induction tasks. These were administered to ensure that the only group differences were on the scales that measured closeness of relationship, and not mood (which could affect pain reports):

The Unidimensional Relationship Closeness Scale (URCS) [15] is a 12-item self-report questionnaire which assesses the closeness of the relationship between the participant and (internal consistency: α = .92 to α = .99 [15]). The questionnaire asked participants to think of the other person from the dyad in the room when responding to the items using a 7-point Likert-scale from 1 *(strongly disagree)* to 7 *(strongly agree)*. Items on the questionnaire were used to assess how close the dyads were to each other: whether the other person is a priority in their life and whether the other person is considered when making important decisions, showing high levels of convergent validity [15]. The more distant the dyad the lower the score will be, and a closer dyad would result in a higher score.

The Relationship Closeness Inventory (RCI) [2] was used to assess the closeness of two people with regards to their interdependence and has been since shown to be a very robust measure in young adults [30]. The items on the questionnaire were combined to give an overall estimation of closeness. The RCI was designed to look closely at the different relationships between people, including romantic couples, friends and family [2]. The RCI has three subscales: the strength, diversity and frequency. The diversity and frequency subscales were considered redundant measures of closeness as they do not include modern ways of communicating [15]. Therefore, only the strength subscale was used in the analysis (internal consistency: $\alpha = .90$ [2]). The higher the score the closer the dyad.

The Depression Anxiety and Stress Scale (DASS) [33] is a 42-item self-report questionnaire that assesses the symptoms of depression, anxiety and stress. The DASS is a well-established measure of mood, and has been used in both clinical and non-clinical settings around the world [7]. All participants were asked to rate on a Likert-scale between 0 (*did not apply to me at all*) and 3 (*applied to me very much*) each question based on the past week. A DASS total score was computed and used for the analysis, as we were interested in general mood differences (internal consistency: $\alpha = .87$ [33]). A higher score indicated a higher negative mood.

2.1.5. Procedure

Ethical approval for the three studies reported here was obtained from the Department of Psychology Ethics Committee and the Department for Health Ethics Committee, University of Bath, UK. Following recruitment, participants provided written consent, completed a demographics form, and were given further instructions about the task. Participants allocated to the pain condition completed the pain induction tasks twice: once with an observer present and once without. In order to account for practice effects, the order in which participants completed the tasks with and without an observer present was counterbalanced. The observers did not complete either of the pain induction tasks, but simply watched the task being conducted on one occasion.

Figure 1 illustrates the set-up of the laboratory during each pain induction task, and shows the positioning of the dyads and experimenter during the study. In the observer present condition, observers were sat directly in front of the participant completing the pain induction task. During the observer absent condition, participants were asked to look in the direction of where the observer would be sat (but of course, were not present). After both pain induction tasks, both participant and observer completed the DASS, URCS, and RCI, and were debriefed. Course credits or a monetary payment were given to all participants and observers.

Figure 1

2.2 Results

2.2.1. Data screening

Data screening of all raw data was conducted following procedures outlined by Tabachnick and Fidell [42]. Outliers were identified by converting the raw scores to z-scores, and considered an outlier if they were ±3.29. This method revealed four outliers (all in the cold pressor task threshold condition, without an observer present), which were adjusted to a value one unit larger/smaller than the next extreme score in the distribution [42]. To ensure that the scores were normally distributed, histograms were generated to visually check for abnormalities, and skewness and kurtosis values checked. The data were normally distributed.

Means and standard deviations for the pain outcomes and self-report questionnaires are in Table 1.

Table 1

The complete analysis for the DASS, URCS and RCI can be found in the online supplementary material. Briefly, on the URCS, friends reported closer relationships than strangers ($p < .001$), and women reported closer relationships than men ($p < .001$). On the DASS, observers had a higher negative mood than participants completing the pain tasks ($p < .05$). There were no other significant differences.

2.2.2. Impact of an observer on reporting of cold pressor pain

To examine the effects of an observer on the experience of pain, a mixed group ANOVA was conducted on each of the cold pressor outcomes (threshold, tolerance, SF-MPQ-2, and VAS pain scores). Each analysis included the sex of the participant experiencing pain within each dyad (male vs. female) and the dyadic relationship (friend vs. stranger) as between-group factors. Observer presence (absent vs. present) was also included as a within-group factor in this analysis. In terms of possible interactions, we predicted that the effects of observer characteristics should only have an effect when the observer was actually present.

For pain thresholds, there was a main effect of participant sex, $F(1,44) = 6.79$, $p < .05$, $\eta_p^2 = .13$. Overall, men ($M = 18.27$ secs, $SD = 14.94$ secs) had a higher pain threshold than women ($M = 8.62$ secs, $SD = 10.24$ secs). In addition, there was a main effect of observer presence, $F(1,44) = 4.56$, $p < .05$, $\eta_p^2 = .09$. Pain thresholds increased when an observer was present ($M = 15.58$ secs, $SD = 18.99$ secs) compared to when they were absent ($M = 11.31$ secs, $SD = 10.03$ secs). However, there was no main effect of dyadic relationship, $F(1,44) = 1.57$, $p > .05$, $\eta_p^2 = .04$, and there were no significant interactions.

A similar analysis was conducted on cold pressor pain tolerance levels. The mean difference in pain tolerance was 26.53 seconds, confirming that men ($M = 53.47$ secs, $SD =$

41.28 secs) had a significantly higher tolerance scores than women (*M* = 26.94 secs, *SD* = 27.85 secs), $F(1,44) = 7.82$, $p < .01$, $\eta_p^2 = .15$. A main effect of observer presence was again found $F(1,44) = 6.13$, $p < .05$, $\eta_p^2 = .12$, indicating higher tolerance levels when an observer was present (*M* = 43.51 secs, *SD* = 39.53 secs) compared to when they were absent (*M* = 36.89 secs, *SD* = 37.29 secs). Additionally, there was a main effect of dyadic relationship, $F(1,44) = 5.32$, $p < .05$, $\eta_p^2 = .11$, in that participants allocated to the friends condition (*M* = 51.16 secs, *SD* = 44.48 secs) tolerated more pain compared to those in the stranger condition (*M* = 29.26 secs, *SD* = 30.02 secs). Interestingly, the critical interaction between dyadic relationship and observer was not significant ($p > .05$), nor were any of the other interactions.

Analysis of the self-report pain measures found no significant effects for SF-MPQ-2 scores. For the VAS scores, a main effect of observer presence was found, $F(1,44) = 6.38$, $p < .05$, $\eta_p^2 = .13$. Self-reported pain levels were higher when an observer was present (*M* = 61.67, *SD* = 18.31) than absent (*M* = 56.65, *SD* = 19.31). No other significant effects were found (all *p's* > .170).

2.2.3. Impact of an observer on reporting of pressure pain

A similar series of ANOVA's were conducted on outcomes from the pressure pain task. For pressure pain thresholds, a main effect of sex was found $F(1,44) = 36.66$, $p < .001$, $\eta_p^2 = .46$, with men (*M* = 874.05 kPa, *SD* = 324.38 kPa) exhibiting a higher thresholds than women (*M* = 459.37 kPa, *SD* = 172.64 kPa). A main effect of observer presence was also found, $F(1,44) = 10.28$, $p < .01$, $\eta_p^2 = .19$, showing that pressure pain thresholds were higher when an observer was present (*M* = 696.83 kPa, *SD* =350.33 kPa) than when absent (*M* = 636.59 kPa, *SD* = 325.25 kPa). When considering the dyadic relationship, a main effect was found, $F(1,44) = 5.91$, $p < .05$, $\eta_p^2 = .12$. Those allocated to the friends group exhibited higher pressure pain thresholds (*M* = 749.94 kPa, *SD* = 424.38 kPa) compared to those in the stranger group (*M* = 583.48 kPa, *SD* = 424.38 kPa). As before, the interaction between dyadic relationship and observer was not significant ($p > .05$). However, a significant interaction was found between dyadic relationship and the sex of the participant, $F(1,44) = 5.27$, $p < .05$, $\eta_p^2 = .11$ (see Figure 2). No other interactions were significant.

Follow-up analysis was conducted on the significant two-way interaction and the appropriate Bonferroni adjustments were made ($p = .0125$). This indicated that when in the friends group, men (*M* = 1094.85 kPa, *SD* = 348.05 kPa) had a significantly higher pressure pain thresholds than women (*M* = 486.47 kPa, *SD* = 231.40 kPa), $t(22) = 5.04$, $p < .001$, $d = 2.06$. A similar difference was found for those in the stranger group: men had higher thresholds (*M* = 725.13 kPa, *SD* = 196.38 kPa) than women (*M* = 480.88 kPa, *SD* = 195.69 kPa) in the stranger group, $t(22) = 3.05$, $p < .01$, $d = 1.25$. However, when looking within men, those in the friends group (*M* = 1094.85 kPa, *SD* = 348.05 kPa) had a significantly higher pressure pain thresholds than those in the strangers group (*M* = 725.13 kPa, *SD* = 196.38 kPa), $t(22) = 3.21$, $p < .01$, $d = 1.31$. No such effect was found for women, however (friends group: *M* = 486.47 kPa, *SD* = 231.40 kPa; strangers group: *M* = 480.88 kPa, *SD* = 195.69 kPa), $t(22) = .06$, $p > .05$, $d = .03$).

Figure 2

For the SF-MPQ-2, a significant main effect of observer presence was found, $F(1,44) = 7.83$, $p < .01$, $\eta_p^2 = .15$. When an observer was present (*M* = 1.40, *SD* = 1.08) pain intensity was lower compared to when absent (*M* = 1.62, *SD* = 1.24). No other significant effects were found.

For pressure pain VAS scores, no significant effects were found.

2.3. Study 1 Discussion

The results of Study 1 confirmed that women reported greater pain compared to men, and men tolerated more pain, which is consistent with previous studies. Importantly, in terms of the key focus of the current study, the presence of an observer also had an effect on how pain was reported. Participants reported higher pain thresholds, and tolerated more pain, when an observer was present, in comparison to when participants were alone. However, this observer effect on pain was only seen in pain threshold and tolerance, and not in the self-report measures.

Interestingly, for pain threshold, this effect occurred independently of whether the observer was a friend or a stranger, suggesting that the nature of the relationship may be less important than the presence of another. However, an effect of observer type was found to impact on cold pressor pain tolerance - cold pressor pain tolerance was higher in the friend condition. Interestingly, this effect was not limited to when the observer was actually present, but also found when the friend was absent (but in the next room). One possible reason for this could be that just the knowledge that a friend was near and could be present during a painful event may be strong enough to affect pain.

Inconsistent results were found across both the self-report questionnaires and pain induction tasks. For example, for the cold pressor pain ratings there were no observer effects, but differences were found for the algometer, whereas a different pattern was found for VAS scores across tasks. These are difficult findings to interpret, as we cannot say whether the inconsistency is due to the measures, the tasks, or both. Explanations for this would be purely speculative, and perhaps the all we can do at this point is note the inconsistency, and conduct further investigation to see whether this really is an unreliable effect.

One unexpected observation was that although no restriction was placed on who was chosen as an accompanying friend (apart from no romantic involvement), all participants brought a friend of the same-sex. This meant that we were unable to consider the possible interaction between same and opposite-sex friends within the current study. In light of this, Study 2 sought to directly investigate this possibility, by controlling the sex of the friendship dyads to see if there are differences in the reporting of pain between same-sex and opposite-sex friends. We hypothesized that: 1. men will have a higher pain threshold and tolerance than women, irrespective of the sex of the friend observing, 2. participants allocated to the same-sex friend's condition will have a higher pain threshold and tolerance than those allocated to the opposite-sex friend's condition.

3. Study 2: Same-sex friends vs. opposite-sex friends

3.1. Method

3.1.1. Design

A similar design was used here as reported in Study 1. The main difference was that no strangers were recruited, but instead observers consisted of either same-sex or opposite-sex friends. Specifically, a mixed-groups design was employed, with two between-groups factors: sex of the participant (male vs. female) and sex of the observer (male vs. female). The within-groups variable was the presence of an observer (observer present vs. observer absent). The dependant variables were various pain response indexes from the two pain induction tasks.

3.1.2. Participants and observers

A total of 96 adults were recruited in a similar way to that described in Study 1, but with a focus on ensuring an equal split of male and female observers. Initially, 48 participants were recruited to take part in a pain study. After initial screening, half of the participants were asked to bring a same-sex friend and the other half were asked to bring an opposite-sex friend with them to the study. The only other stipulation was that there was no romantic involvement with the friend. The friend did not complete any of the pain tasks, but instead observed.

Therefore, the 96 individuals comprised of four groups of 12 dyadic same/different sex pairs i.e., male-male, male-female, female-female, female-male. Within each pair, one person served as an observer (24 male; *M* = 24.25 years, *SD* = 7.69 years, 24 female; *M* = 20.29, years *SD* = 3.11 years) and the other took part in the pain induction tasks (24 male; *M* = 24.21 years, *SD* = 7.60 years and 24 female; *M* = 19.67 years, *SD* = 2.35 years).

3.1.3. Procedure

The procedure followed here was the same as described in Study 1. Participants completed the cold pressor and pressure pain task alone and with an observer (order was counterbalanced between pairs). The same questionnaires measures were also administered, in the same way. The only differences between studies was the nature of the dyadic pairings. All participants were reimbursed for their participation.

3.2. Results

3.2.1. Data screening and group dyad manipulation check

Screening of the raw data was conducted using the techniques described in study 1. Outliers were identified by data with z-scores ±3.29. This revealed one outlier for pain threshold on the cold pressor task when an observer was present, which was adjusted to a value one unit larger than the next score [42]. Histograms, and skewness and kurtosis values were checked, which confirmed normal distributions for all variables.

The means and standard deviations for each of the pain induction tasks and the self-report questionnaires are in Table 2.

Table 2

The analysis for the DASS, URCS and RCI (see online supplementary material) showed no differences in the relationship closeness or mood differences between participants.

3.2.2. Impact of an observer on the reporting of cold pressor pain

A series of ANOVA's were conducted on the cold pressor pain outcomes, and where relevant, follow-up t-tests with Bonferroni corrections. The between groups variables were sex of participant (male vs. female), sex of the observer (male vs. female) and the within groups factor was observer presence (absent vs. present).

For pain thresholds, a main effect of sex of the participant was found, $F(1,44) = 12.60$, $p < .001$, $\eta_p^2 = .22$. Men ($M = 14.37$ secs, $SD = 10.34$ secs) had higher cold pressor pain thresholds than women ($M = 6.88$ secs, $SD = 10.34$ secs). No other significant effects were found.

For pain tolerance a significant effect of participant sex was found, $F(1,44) = 28.37$, $p < .001$, $\eta_p^2 = .39$. Men ($M = 68.38$ secs, $SD = 45.38$ secs) exhibited a higher pain tolerance than women ($M = 20.91$ secs, $SD = 17.14$ secs). Additionally, there was a main effect of observer presence, $F(1,44) = 13.98$, $p < .001$, $\eta_p^2 = .24$, with pain tolerance levels being higher when the observer was present ($M = 49.82$ secs, $SD = 44.46$ secs) compared to when absent ($M = 39.47$ secs, $SD = 39.14$ secs). Sex of the observer was also significant, $F(1,44) = 5.44$, $p < .05$, $\eta_p^2 = .11$. Pain tolerance was higher amongst participants allocated to the male observer group ($M = 61.64$ secs, $SD = 46.93$ secs) compared to the female observer group ($M = 38.01$ secs, $SD = 39.31$ secs).

There was also a significant two-way interaction between sex of the participant and the sex of the observer, $F(1,44) = 4.19$, $p < .05$, $\eta_p^2 = .09$ (see Figure 3). After Bonferroni adjustments (.05/4 = .0125), analysis revealed that when in the male observer condition, male participants ($M = 96.50$ secs, $SD = 38.32$ secs) exhibited higher pain tolerance levels than women (M = 26.79 secs, SD = 22.06 secs), $t(22) = 5.46$, $p < .001$, $d = 2.23$. However, when in the female observer condition, male participants (M = 54.16 secs, SD = 46.34 secs) were not significantly different from women (M = 21.85, SD = 2.69 secs); $t(22) = 2.24$, $p > .0125$, $d = .89$. Furthermore, male participants placed in the male friend condition exhibited a statistically similar pain tolerance level to when placed in the female observer condition, $t(22) = 2.44$, $p > .0125$, $d = 1.00$. Similarly, within female participants, no significant differences were found between those in the male observer and female observer conditions, $t(22) = .54$, $p > .05$, $d = .22$.

Figure 3

No significant effects were found for SF-MPQ-2 and VAS.

3.2.2. Impact of an observer on the reporting of pressure pain

For pressure pain, a main effect was found for the sex of the participant, $F(1,44) = 11.47$, $p < .001$, $\eta_p^2 = .21$. Men (M = 646.56 kPa, SD = 227.77 kPa) had a higher pressure-pain threshold than women (M = 447.75 kPa, SD = 170.89 kPa). Additionally, there was a main effect of having an observer present $F(1,44) = 25.23$, $p < .001$, $\eta_p^2 = .36$, with higher pressure pain thresholds found when an observer was present (M =589.44 kPa, SD = 255.10 kPa) compared to when they were absent (M = 504.88 kPa, SD = 203.55 kPa). No other significant effects were found.

For the SF-MPQ-V2 no significant differences were found. However, for the VAS, a main effect of participant sex was found, $F(1,42) = 5.06$, $p < .05$, $\eta_p^2 = .11$, in that women (M = 40.50, SD = 20.20) reported higher intensity pain than men (M = 27.93, SD = 18.64). A significant interaction was found between the sex of the participant and presence of an observer, $F(1,42) = 5.00$, $p < .05$, $\eta_p^2 = .11$ (see Figure 4). Follow-up analysis revealed that when the observer was absent, men ($M = 28.87$, $SD = 19.34$) and women ($M = 38.30$, $SD = 20.43$) reported similar pain levels, $t(44) = -1.61$, $p > .0125$, $d = -.47$. However, when an observer was present, women ($M = 42.70$, $SD = 21.60$) reported their pain as being more intense than men ($M = 27.00$, $SD = 18.57$), $t(44) = -2.64$, $p = .011$, $d = -.78$. No other significant effects were found.

Figure 4

3.3. Study 2 Discussion

Several patterns emerged from Study 2. First, and in line with the results from Study 1, women reported a lower pain threshold and tolerance than men. Again the presence of an observer had an effect on the way pain was reported, particularly for pain tolerance when the observer was present. Interestingly, there was also a sex difference in the effect of having a friend present (of either sex) on self-reported pain. Women rated their pain as more intense than men when in the presence of a friend, even though this was not found in actual pain thresholds.

The primary aim of Study 2 was to identify sex differences in pain when accompanied by either a same-sex or opposite-sex friend. While effects were found, like Study 1 they generalized across observer present and absent conditions. Specifically, pain was tolerated the most when the dyad comprised of two men. One reason why men might exhibit higher tolerance to pain when accompanied by a same-sex friend could be because where pain expression is perceived as a visible marker of vulnerability, men are more likely to supress pain communication in the presence of other men. If this is the case, then for men, presenting vulnerability (i.e., pain) may be most likely to occur when competition is low [24], such as when in the presence of a very close opposite-sex acquaintance. Research suggests that women have a wider range of social support networks, whereas men tend to rely more on a spouse for support [25]. From this we might predict that men would be most willing to disclose pain when accompanied by a close romantic partner.

In order to explore this possibility, Study 3 investigated whether men would show a lower tolerance to pain in the presence of a romantic partner. It was hypothesised that: 1. participants (especially men) would be more likely to report pain (i.e., exhibit lower pain threshold and tolerance) when accompanied by their romantic partner compared to a friend they were not romantically involved with.

4. Study 3: Romantic partners vs. opposite-sex friends

4.1. Method

4.1.1. Design

As in previous studies, a mixed-groups design was employed. There were two between-groups factors: sex of the participant (male vs. female) and the dyadic relationship (romantic partner vs. opposite-sex friend). The within-groups variable was the observer (observer present vs. observer absent). The dependant variables were pain response indexes from the two pain induction tasks.

4.1.2. Self-report measures

As well as including the same self-report measures described in previous studies, the Experiences in Close Relationships-Revised (ECR-R) [20] was included, which has been shown to be a reliable psychometric measure of romantic attachments in adults [41]. This scale assesses individual differences in attachment-related anxiety ($\alpha = .93$ [20]) (how secure someone feels with regards to availability and responsiveness of their partner/others) and attachment-related avoidance ($\alpha = .95$ [20]) (the extent to which people are uncomfortable being close to their partner/others), which may be relevant to how close the romantic relationship is. The ECR-R comprises of 36 items, which are rated on a Likert-scale between 1 (*strongly disagree*) to 7 (*strongly agree*). Questionnaires were scored in line with the guidance from Fraley, Waller and Brennan [19], whereby scoring high on both scales would indicate the person is fearful-avoidant, and lower scores on both scales indicates feeling secure with the relationship.

4.1.3. Participants and procedure

A total of 96 participants were recruited into Study 3, which comprised of 48 dyads. Of these 24 dyads were opposite-sex romantic partners (*M* length of relationship = 35.62 months, *SD* = 23.56 months) and 24 dyads were opposite-sex friends. Within each dyad, one person completed the pain induction tasks (24 male; *M* = 25.42 years *SD 5.11* years, 24 female; *M* = 23.92 years *SD* = 4.23 years) and one observed (24 male; *M* = 25.38 years *SD* = 6.01 years, 24 female; *M* = 24.25 years *SD* = 4.20 years).

Participants were recruited using a similar approach as Study 2. Initially, 48 participants were recruited to take part in the pain induction tasks, and were made aware that they would have to bring in either a friend or a romantic partner of the opposite-sex to observe. On the day of testing, the same pain induction procedures and measures were administered, as outlined in the previous studies (alongside the ECR-R).

4.2. Results

4.2.1. Data screening and group dyad manipulation check

Data were checked for potential outliers using z-scores (±3.29), but none were found. Histograms and the skewness/kurtosis values confirmed that normality was met. The means and standard deviations for pain induction task and the self-report measures are presented in Table 3.

Table 3

The analysis for the DASS, URCS, ECR-R and RCI can be found in the online supplementary material. For the URCS, romantic partners reported closer relationships than the participants in the friend's condition ($p < .001$). On the ECR-R, opposite-sex friends had higher avoidance scores than the romantic partners ($p < .001$). Finally, for the DASS, romantic partners had a lower mood than those in the friend's condition ($p < .05$).

4.2.2. Impact of an observer on the reporting of cold pressor pain

A series of ANOVA's were conducted on the cold pressor outcomes, with the sex of the person experiencing pain (male vs. female), the dyadic relationship (opposite-sex romantic partners vs. opposite-sex friends) as between-group factors, and the observer presence (observer absent vs. observer present) as a within-group factor.

For pain threshold, there was a main effect of observer presence, $F(1,44) = 4.34$, $p < .05$, $\eta_p^2 = .09$. Pain thresholds were lower when the observer was absent ($M = 7.49$ secs, $SD = 5.93$ secs) compared to when present ($M = 9.28$ secs, $SD = 6.86$ secs). There were no other significant effects.

For pain tolerance, a significant effect of participant sex was found, $F(1,44) = 18.68$, $p < .001$, $\eta_p^2 = .30$. Men ($M = 61.46$ secs, $SD =$ secs) had a higher pain tolerance than women ($M = 19.00$ secs, $SD =$ secs). Additionally, there was a main effect of observer presence, $F(1,44) = 4.36$, $p < .05$, $\eta_p^2 = .09$. Pain tolerance was higher when participants were accompanied by an observer ($M = 42.37$ secs, $SD = 40.34$ secs) than when tested alone ($M = 38.09$ secs, $SD = 39.69$ secs). No other significant effects were found.

For the SF-MPQ-V2 and VAS, no significant differences were found.

4.2.3. Impact of an observer on the reporting of pressure pain

For the pressure pain task, a significant effect of sex was found, $F(1,44) = 10.49$, $p < .01$, $\eta_p^2 = .19$. Men ($M = 437.11$ kPa, $SD = 120.15$ kPa) had a higher pressure pain threshold than women ($M = 326.11$ kPa, $SD = 131.22$ kPa). No other significant effects were found.

For the SF-MPQ-V2 no significant effects were found. There was no main VAS effect, however, there was a significant interaction between observer presence and dyadic relationship, $F(1,40) = 5.39$, $p < .05$, $\eta_p^2 = .12$. Post-hoc analysis with a Bonferroni adjustment indicated that there were no significant differences between the groups (all p's > .0125). Inspection of means were examined, which suggested that those pain ratings were slightly lower when the romantic partner was absent, compared to when present.

4.3 Study 3 Discussion

As expected, participants in the romantic partner's condition reported closer relationships with their observer than those in the opposite-sex friends group. Pain reports were also affected by the presence of an observer, with more pain being tolerated when an observer was present. However, although we expected pain tolerance to be higher when men were in the presence of an opposite-sex friend, compared to a romantic partner, the nature of the dyadic relationship did not affect pain behaviour.

5. General discussion

The key finding from these three studies is that the presence of an observer can affect the report of pain, and that in some situations, both the nature of relationship and sex of the dyad are relevant also. Specifically, pain threshold and tolerance increased most when dyads comprised of same-sex friends. Study 1 compared friends and strangers, and found that those in the friend's condition (which were all same-sex friends) had a higher pain tolerance. When the type of friendship (i.e., sex of friends) was investigated in Study 2, those in the same-sex condition had higher pain tolerance compared to those in the opposite-sex group. Here the effects of same-sex friends on pain was strongest when the dyads comprised of male-male pairs. Interestingly, Study 3 found no difference between the opposite-sex romantic partners and opposite-sex friends, suggesting that when dyads are of mixed-sex pairs, closeness of dyadic relationship does not alter pain threshold or tolerance.

Throughout the three studies there was also a consistent, general, observer effect, in that increased pain tolerance was found when participants were accompanied by an observer. Whilst consistent with previous pain studies into observer effects [32; 34; 45], one difference found here was that observers affected the behavioural measures (e.g., tolerance), and not the self-report measures of pain. One possibility could be that the presence of an observer did not actually change pain experience, but instead resulted in participants not wanting to disclose pain during the task, thus resulted in them sustaining the experiences for longer. However, the fact that other (similar) studies have found observers impact self-report of pain would seem to mitigate against this explanation. It is, therefore, not clear why a difference across these pain measures was found here.

The primary aim of this investigation was, however, to examine whether the type of observer, with a particular focus on the role of friends, has an impact on pain reporting behaviours. Friendship, and the effect it has on pain reporting is largely under researched, but our findings complement the few studies that have been reported [34] . The sex of the friend was important, in that men reported less pain when in the presence of a same-sex friend. This contrasts with previous work, which tends to examine the effects of same-sex strangers, rather than friends, yet seems to find similar pain suppression patterns in male-male dyads [34]. Reasons for this vary, but may be linked to stereotypical patterns of male behaviours.

For example, men are typically considered to be more stoic, less likely to express their emotions in an everyday context, and so maybe less likely to be seen drawing on social support – especially from other men [17]. Competition between men may also play a role [37], especially during adolescence and early adulthood. Research suggests that men often want male peers to view them favourably [40], and so it is possible that same-sex male friends produces a more competitive environment within which friendship dyads operate [3]. In comparison, same-sex female friends may be more likely to focus on friendship around social support and intimacy, and be less inhibited to express signals associated with pain [39]. If so, it is possible that men and women interact with same and opposite-sex friends in different ways, and it would be interesting to consider these issues further, especially in terms of interpersonal competition.

Our findings enhance what is known about how we communicate pain in social settings [34; 45; 46]. We know that pain is communicated through nonverbal signs, such as facial expressions [13] and body posture [48], whereas less is known about how the type of people we interact with affects pain experiences, beyond simple familiarity. The nature of the relationship between participants and observer is important [29], although friendship is rarely considered. For example, a systematic review of 26 studies found that the majority of studies compared strangers and social partners, with only four specifically looking at the effect of friends [29]. Furthermore, of the friend studies, few took the gender of dyads into consideration. Our results confirm that this is a potentially important oversight and should be corrected within future studies [25].

Study 3 findings are interesting in light of research into empathy and social support from partners/spouses [31]. Here it has been found that support from a partner can decrease pain intensity [6; 46], especially when an individual perceives himself or herself as receiving social support from their partner. However, we did not find that the presence of a romantic partner reduced pain (when compared to opposite-sex friends). Whilst romantic partners were rated as having closer relationships than friends, it would be unwise to assume this is a proxy for perceived support. It would be useful to explore the potential role of support and attachment between dyads in future sex-based studies on observer effects. In addition, the length of relationships in our romantic partners may be important. Although the average length of relationships was around 3 years, there was a wide range of scores. Couples who have been in long-term relationships may differ from those who have only recently established a relationship.

Although interesting, we do need to be mindful of potential design limitations before drawing definite conclusions. For example, it could be argued that since participants were recruited as stranger, they attended the same University, and so could share a collective group identity [5]. We need to explore whether variation in perceived social identity moderates any effect that 'strangers' may have on pain reports. Second, the experimenter was physically present throughout the study, and whilst 'hidden' from view, it could be argued that there was not a truly alone condition. As the experimenter was consistent across both sessions, what we might be measuring here is the effect of adding a friend, stranger or romantic partner to an existing stranger-based social setting. Further issues to consider are the pain induction paradigm and use of non-clinical samples. Naturally occurring pain is difficult to stop and control, as it is possible to do in the laboratory. Knowledge that one can withdraw at any time and stop the pain undoubtedly has an effect on how people behave, and perhaps this knowledge also plays a role in how we act in front of an observer. However, we view experimental work such as this as an essential first step in starting to understand the impact of different dyadic interactions on pain; it guides us in potentially useful directions. Our results suggest that the gendered context of pain is worth considering within clinical pain settings.

Despite these limitations, there are implications for future research, For example, we should consider the stability of the same-sex observer effect in men. The presence of competitiveness between friends may influence the way pain is communicated. It would also be interesting to consider whether competitiveness between friends occurs more within same-sex dyads, and in particular male-male interactions. We could also consider whether the knowledge of having others present is enough to elicit an observer effect, or whether the observer needs to be physically present before these effects are observed. As well as examining same and opposite-sex dyads, we could also examine same and opposite gender dyads – something that has not yet been considered in pain.

Although we did not address clinical pain here, if these effects translate beyond experimental analogues, there are some potential interesting, although speculative, implications. One possibility might be to see whether we should extend the opportunities for those undergoing painful procedures to be accompanied by a supportive observer. This is not a new idea of course, and there is relevant research into the impact birth partners can have on women's experiences of childbirth, including pain [27]. This area considers women's choices and preferences around who is best suited to provide support. Perhaps we can learn more about the qualities a supportive observer might bring to patient's pain-related experiences (e.g., empathy [23; 31]). We could also consider whether the gendered context translates to clinical pain settings, by looking at whether patients report their pain differently, depending on whether their healthcare professional is male or female, and whether they are strangers or are known to each other. There is emerging evidence that healthcare professionals might interpret nonverbal pain signals from male and female patients in different ways [49].

To conclude, these studies demonstrate that the presence of another, observing a person in pain, impacts on how much pain is reported. It also suggests that both the nature of the relationships between participants and observers, as well as the sex of the dyads might also moderate how pain is reported. Interestingly, it was concluded that all-male dyads of friends result in less pain being reported.

Acknowledgements

This research was made possible by a studentship awarded by the University of Bath awarded to the first author.

Conflict of interest

The authors have no conflicts of interest to declare.

References

[1] Bartley E, Fillingim R. Sex differences in pain: a brief review of clinical and experimental findings. British journal of anaesthesia 2013;111(1):52-58.
[2] Berscheid E, Snyder M, Omoto AM. The Relationship Closeness Inventory: Assessing the closeness of interpersonal relationships. Journal of Personality and Social Psychology 1989;57(5):792-807.
[3] Booth A, Nolen P. Choosing to compete: How different are girls and boys? Journal of Economic Behavior & Organization 2012;81(2):542-555.
[4] Brannan D, Biswas-Diener R, Mohr CD, Mortazavi S, Stein N. Friends and family: A cross-cultural investigation of social support and subjective well-being among college students. The Journal of Positive Psychology 2013;8(1):65-75.
[5] Brewer MB, Pierce KP. Social identity complexity and outgroup tolerance. Personality and Social Psychology Bulletin 2005;31(3):428-437.
[6] Brown JL, Sheffield D, Leary MR, Robinson ME. Social support and experimental pain. Psychosomatic Medicine 2003;65(2):276-283.
[7] Brown TA, Chorpita BF, Korotitsch W, Barlow DH. Psychometric properties of the Depression Anxiety Stress Scales (DASS) in clinical samples. Behaviour research and therapy 1997;35(1):79-89.
[8] Cano A, Barterian JA, Heller JB. Empathic and nonempathic interaction in chronic pain couples. The Clinical journal of pain 2008;24(8):678-684.
[9] Cano A, Gillis M, Heinz W, Geisser M, Foran H. Marital functioning, chronic pain, and psychological distress. Pain 2004;107(1-2):99-106.
[10] Cano A, Johansen AB, Geisser M. Spousal congruence on disability, pain, and spouse responses to pain. Pain 2004;109(3):258-265.
[11] Chesterton LS, Barlas P, Foster NE, Baxter GD, Wright CC. Gender differences in pressure pain threshold in healthy humans. Pain 2003;101(3):259-266.
[12] Chow CM, Ruhl H, Buhrmester D. The mediating role of interpersonal competence between adolescents' empathy and friendship quality: A dyadic approach. Journal of adolescence 2013;36(1):191-200.
[13] Craig KD. The facial expression of pain Better than a thousand words? APS Journal 1992;1(3):153-162.
[14] Craig KD. The social communication model of pain. Canadian Psychology/Psychologie canadienne 2009;50(1):22-32.
[15] Dibble JL, Levine TR, Park HS. The Unidimensional Relationship Closeness Scale (URCS): reliability and validity evidence for a new measure of relationship closeness. Psychological assessment 2012;24(3):565-572.
[16] Dworkin RH, Turk DC, Revicki DA, Harding G, Coyne KS, Peirce-Sandner S, Bhagwat D, Everton D, Burke LB, Cowan P, Farrar JT, Hertz S, Max MB, Rappaport BA, Melzack R. Development and initial validation of an expanded and revised version of the Short-form McGill Pain Questionnaire (SF-MPQ-2). Pain 2009;144(1–2):35-42.
[17] Eagly AH. Sex differences in social behavior: A social-role interpretation: Psychology Press, 2013.
[18] Fillingim RB, King CD, Ribeiro-Dasilva MC, Rahim-Williams B, Riley JL, 3rd. Sex, gender, and pain: a review of recent clinical and experimental findings. The journal of pain : official journal of the American Pain Society 2009;10(5):447-485.
[19] Fraley RC, Heffernan ME, Vicary AM, Brumbaugh CC. The experiences in close relationships—Relationship Structures Questionnaire: A method for assessing attachment orientations across relationships. Psychological assessment 2011;23(3):615-625.

[20] Fraley RC, Waller NG, Brennan KA. An item response theory analysis of self-report measures of adult attachment. Journal of personality and social psychology 2000;78(2):350.
[21] Gauthier LR, Young A, Dworkin RH, Rodin G, Zimmermann C, Warr D, Librach SL, Moore M, Shepherd FA, Pillai Riddell R, Macpherson A, Melzack R, Gagliese L. Validation of the Short-Form McGill Pain Questionnaire-2 in Younger and Older People With Cancer Pain. The Journal of Pain 2014;15(7):756-770.
[22] Hastie BA, Riley Iii JL, Kaplan L, Herrera DG, Campbell CM, Virtusio K, Mogil JS, Wallace MR, Fillingim RB. Ethnicity interacts with the OPRM1 gene in experimental pain sensitivity. Pain 2012;153(8):1610-1619.
[23] Hurter S, Paloyelis Y, de C. Williams AC, Fotopoulou A. Partners' Empathy Increases Pain Ratings: Effects of Perceived Empathy and Attachment Style on Pain Report and Display. The Journal of Pain 2014;15(9):934-944.
[24] Karen D, Washington RE. Sociological Perspectives on Sport: The Games Outside the Games: Routledge, 2015.
[25] Keogh E. Gender differences in the nonverbal communication of pain: A new direction for sex, gender, and pain research? Pain 2014.
[26] Keogh E, Hatton K, Ellery D. Avoidance versus focused attention and the perception of pain: differential effects for men and women. Pain 2000;85(1-2):225-230.
[27] Keogh E, Hughes S, Ellery D, Daniel C, Psy DC, Holdcroft A. Psychosocial Influences on Women's Experience of Planned Elective Cesarean Section. Psychosomatic Medicine 2006;68(1):167-174.
[28] Kinser AM, Sands WA, Stone MH. Reliability and validity of a pressure algometer. Journal of strength and conditioning research / National Strength & Conditioning Association 2009;23(1):312-314.
[29] Krahe C, Springer A, Weinman JA, Fotopoulou A. The social modulation of pain: others as predictive signals of salience - a systematic review. Frontiers in human neuroscience 2013;7:386.
[30] Laursen B, Williams VA. Perceptions of interdependence and closeness in family and peer relationships among adolescents with and without romantic partners. New Directions for Child and Adolescent Development 1997;1997(78):3-20.
[31] Leong LE, Cano A, Wurm LH, Lumley MA, Corley AM. A Perspective-Taking Manipulation Leads to Greater Empathy and Less Pain During the Cold Pressor Task. The journal of pain : official journal of the American Pain Society 2015;16(11):1176-1185.
[32] Levine FM, De Simone LL. The effects of experimenter gender on pain report in male and female subjects. Pain 1991;44(1):69-72.
[33] Lovibond PF, Lovibond SH. The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. Behaviour research and therapy 1995;33(3):335-343.
[34] McClelland L, McCubbin J. Social influence and pain response in women and men. J Behav Med 2008;31(5):413-420.
[35] Mitchell LA, MacDonald RAR, Brodie EE. Temperature and the cold pressor test. The Journal of Pain 2004;5(4):233-237.
[36] Myers CD, Robinson ME, Riley JL, Sheffield D. Sex, gender, and blood pressure: contributions to experimental pain report. Psychosomatic Medicine 2001;63(4):545-550.
[37] Niederle M, Vesterlund L. Do Women Shy Away From Competition? Do Men Compete Too Much? The Quarterly Journal of Economics 2007;122(3):1067-1101.

[38] Price DD, McGrath PA, Rafii A, Buckingham B. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain 1983;17(1):45-56.
[39] Reis HT, Senchak M, Solomon B. Sex differences in the intimacy of social interaction: Further examination of potential explanations. Journal of Personality and Social Psychology 1985;48(5):1204-1217.
[40] Ricciardelli LA, McCabe MP, Banfield S. Body image and body change methods in adolescent boys. Role of parents, friends and the media. J Psychosom Res 2000;49(3):189-197.
[41] Sibley CG, Liu JH. Short-term temporal stability and factor structure of the revised experiences in close relationships (ECR-R) measure of adult attachment. Personality and Individual Differences 2004;36(4):969-975.
[42] Tabachnick BG, Fidell LS. Using Multivariate Statistics (5th Edition): Allyn \& Bacon, Inc., 2006.
[43] Vervoort T, Caes L, Trost Z, Sullivan M, Vangronsveld K, Goubert L. Social modulation of facial pain display in high-catastrophizing children: an observational study in schoolchildren and their parents. Pain 2011;152(7):1591-1599.
[44] Vervoort T, Huguet A, Verhoeven K, Goubert L. Mothers' and fathers' responses to their child's pain moderate the relationship between the child's pain catastrophizing and disability. Pain 2011;152(4):786-793.
[45] Vigil JM, Coulombe P. Biological sex and social setting affects pain intensity and observational coding of other people's pain behaviors. Pain 2011;152(9):2125-2130.
[46] Vigil JM, Rowell LN, Chouteau S, Chavez A, Jaramillo E, Neal M, Waid D. Sex Differences in How Social Networks and Relationship Quality Influence Experimental Pain Sensitivity. PLoS ONE 2013;8(11):e78663.
[47] von Baeyer CL, Piira T, Chambers CT, Trapanotto M, Zeltzer LK. Guidelines for the cold pressor task as an experimental pain stimulus for use with children. The Journal of Pain 2005;6(4):218-227.
[48] Walsh J, Eccleston C, Keogh E. Pain communication through body posture: The development and validation of a stimulus set. PAIN® 2014.
[49] Williams AC, Craig KD. Updating the definition of pain. Pain 2016;157(11):2420-2423.

Table 1: Means and standard deviations (in parenthesis) for pain measures and questionnaires by dyadic relationship (friends vs. strangers), the phase (no observer vs. observer) and participant sex (male vs. female).

Table 2: Means and standard deviations (in parenthesis) for pain measures and questionnaires by dyadic (same-sex friends vs. opposite-sex friends), the phase (no observer vs. observer) and sex (male vs. female).

Table 3: Means and standard deviations (in parenthesis) for pain measures and questionnaires by dyadic (romantic partners vs. opposite-sex friends), the phase (no observer vs. observer) and sex (male vs. female).

Figure 1. A representation of the participant and observer paradigm.

Figure 2. Mean pressure threshold (kPa) for male and female participants in the friends and strangers group. Error bars represent ± 1 standard error of the mean (Study 1).

Figure 3. Mean tolerance time for the cold pressor (secs) for male and female participants with a male and female observer. Error bars represent ± 1 standard error of the mean (Study 2).

Figure 4. Mean VAS score for the algometer (seconds) for male and female participants with and without an observer present for study 2. Error bars represent ± 1 standard error of the mean.