Exploring attentional biases towards facial expressions of pain in men and women

E. Keogh [a,b *], F. Cheng [a], & S. Wang [a,b]

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

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

*Correspondence: Edmund Keogh, Department of Psychology & Centre for Pain Research, University of Bath, Claverton Down, Bath, BA2 7AY, United Kingdom, Tel: +44(0)1225 383671; Fax: +44(0)1225 386752; E-mail: e.m.keogh@bath.ac.uk; URL: http://www.bath.ac.uk/pain

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Significance: Sex-related factors seem to affect how observers view the pain of others. Our results point to an early attentional mechanism that orients the attention of observers away from female expressions of pain.

Abstract

Background: Interpersonal factors may help explain why men and women differ in their perception and expression of pain. Whilst the focus is often on the person in pain, how observers respond to those in pain is important. This study explored whether male-female differences exist in the way observers attend to expressions of pain in others.

Methods: 53 adults (26 females) completed a visual dot-probe task, to measure selective attentional biases to facial expressions of pain and fear. Expression pairs (e.g., pain/neutral) were displayed by either the same male or female actor, and in two different viewing duration conditions: 150 msec and 1250 msec. Dot-probes appeared in either a congruent or incongruent location to the target expression.

Results: No evidence was found for sex-related attentional biases towards pain or fear. However, when examining congruency and incongruency indexes separately, differences emerged. The congruency index analysis indicated that in the 150 msec presentation condition both men and women were slower during congruent female pain/neutral trials when compared to neutral/neutral trials, and relatively faster at responding during congruent male pain/neutral trials.

Conclusions: There is utility in exploring the attentional processes involved in the decoding of pain-related expressions to understand the influence of sex and gender differences in pain. Although male-female differences were found, this was most clearly related to the actor. Our results point to an early attentional mechanism that orients attention away from female expressions of pain. Future consideration of sex- and gender-related contextual factors in attentional processing is warranted.

1. Introduction

Pain is influenced by interpersonal factors, including the sex and gender context (Craig 2009; Keogh 2014). The sex of an observer affects responses to experimental pain, and interactions around clinical pain e.g., child-parent, spouses (Boerner et al., 2017; Edwards et al., 2017; Newton-John and Williams 2006). Judgements and treatment decisions by healthcare professionals can vary according to the sex of the person in pain (Bernardes and Lima 2011; Hirsh et al., 2009; Schafer et al., 2016), and so understanding how sex-related factors operate could help reduce treatment biases.

Different cognitive mechanisms could affect how an observer processes and responds to signals of pain in others. Studies have explored whether male and female observers differ in their recognition accuracy for pain (Keogh 2014). Some find female observers are more accurate in recognising pain in others (Hill and Craig 2004), or more sensitive to detecting pain expressions (Prkachin et al., 2004). However, others report no differences, or alternative patterns (Riva et al., 2011; Simon et al., 2008). For example, Riva et al. (2011) found the sex of the person displaying pain is important -- female pain expressions were more difficult to recognise than those displayed by males.

The exploration of sex-related differences in pain decoding should not be limited to recognition paradigms -- there may be differences in the way painful expressions are initially detected or selected. After all, in order to recognise an expression, one needs to have attended to it first. Although sex-related attentional biases for pain have not been adequately explored, there is evidence from emotion and sex difference research that suggests this may be worth investigating (Carr et

al., 2016; Pfabigan et al., 2014; Pintzinger et al., 2016; Sass et al., 2010; Snowden et al., 2016). For example, Carr et al. (2016) found females, but not males, displayed attentional biases towards threat. When Snowden et al. (2016) presented image pairs of men and women, male participants oriented attention towards female images, whereas females showed no preference. Extrapolating these effects to pain, sex-related factors might influence selective attention towards pain expressions.

We therefore adapted a well-utilized approach to measuring selective attentional biases in pain and anxiety, the dot-probe task (Crombez et al., 2013; Schoth et al., 2012), to include males and females displaying facial expressions of pain and fear. This task not only allows us to determine whether observers' attention is biased towards or away from expressions of pain, but also examine two possible processes: early vigilance for threat, or difficulty in disengaging attention (Baum et al., 2013; Brookes et al., 2017; Tran et al., 2013). A second aim was to explore these two processes. We predicted that female observers would show a (1) stronger attentional bias towards painful expressions; (2) greater early vigilance for painful expressions, and (3) slower disengagement from such expressions. Based on evidence for a decoding bias towards male expressions of pain (Riva et al., 2011) and fear (Trnka et al., 2015), we expected stronger attentional biases towards expressions of pain in men.

2. Methods

2.1 Design

A mixed-groups design was employed. The between-groups factor was the sex of observer (male vs. female), whereas the within-groups factors were stimulus presentation duration (150 msec vs. 1250 msec), sex of actor (male vs. female),

expression-pair type (fear/neutral, pain/neutral, neutral/neutral), threat target face location (left vs. right) and target dot location (left vs. right). The dependent variable was the mean correct response time (RT) latency.

2.2 Participants

A total of 53 adults were opportunistically recruited from the student population of the University of Bath. There were 26 females and 27 males, aged between 19 and 24 years (mean = 21.02, SD = 1.01). There were no significant sex differences in age. The target sample size was determined prior to data collection to be 25 male and 25 female, and was based on similar numbers recruited in two previous unpublished studies that examine for male-female differences in attentional biases to pain expression images (Keogh et al., in preparation). All participants reported being in general good health, and not currently taking pain medication.

2.3 Facial expression images

The images used in the current study were derived from the STOIC database (Roy et al., 2007), and were the same as those previously reported in similar pain decoding studies (Wang et al., 2015; 2017). The original STOIC database comprises a validated set of static and dynamic facial expressions of core emotions, as well as pain and neutral expressions. The expressions are depicted by male and female actors, and have been validated in terms of accurate recognition by observers. In addition to the initial validation study (Roy et al., 2007), we have reported additional validation work in our previous studies into pain decoding (Wang et al., 2015). Briefly, expression images from a range of different expression types were rated in terms of arousal and valance, and expression groups matched in terms of their

similarity or difference to pain. Pain and fear were found to be most similar in terms of both these variables, and was the reason for including fear alongside pain within the current study.

The images used here comprised of 10 actors (5 female and 5 male actors), of which eight (4 male and 4 female) were used in the main experimental task, and 2 actors (1 female and 1 male) used for the practice trials. Each actor depicted the three core facial expressions of interest: pain, fear and neutral. Fear was included as a comparison negative expression to that of pain. This allows us to test the specificity of any biases found, and determine whether they are specific to pain or represent more of a general bias towards negative expressions. The selection of actors was based on a previously reported study (Wang et al., 2015), which demonstrated that the images depicted the core expression under consideration.

Therefore, a total of 24 different face images (8 actors × 3 expressions) were used as stimuli in the main task, and 6 different images for the practice trials (2 actors × 3 expressions). A key aspect of the current study materials was that the same actor depicted each expression. Since the dot-probe task (see next section) presents pairs of expressions, we were therefore able to ensure that the two expression images (e.g., pain/neutral) were of the same actor, thus controlling for any differences in identity – the only difference was the expression depicted in each image pairing. This is different to many other studies, where the identity, including the sex of the actor, is not controlled for. Whilst we would argue that this level of control is a considerable advantage, the nature of the task, and a limited number of actor images available does mean that in the current study the neutral expressions appeared more often than either the pain or fear expressions. Whilst it is not uncommon to include more neutral trials, they are often of different neutral stimuli

(actors or words). We took the decision here that the control over identity was an important feature to retain, although we should acknowledge that this means the neutral expressions appear more often than targets, despite participants viewing each actor the same number of times. This point is returned to in the discussion.

2.4 Dot-probe task

The attentional dot-probe task used in the current study was similar to that used in previously published studies (Baum et al., 2013; Brookes et al., 2017; Keogh et al., 2001; Keogh et al., 2003). The task was controlled using E-Prime professional 2.0.

Initially, a small fixation cross was presented on a computer screen for 500 msec. Then, a pair of images were displayed side-by-side, one to the left, and one to the right, of the initial fixation point. Each image pair comprised of the same actor, displaying either the same or a different expression. One expression was neutral, whereas the other depicted either fear, pain or the same neutral expression. The target expression (pain or fear) could appear in either the left- or right-hand location. The image pairs were presented on the computer screen for a set duration of either 150 msec or 1250 msec. Following the offset of the image pairs, a dot-probe appeared in the location of one of the image pairs, to which participants were instructed to indicate the position of the dot (i.e., on either the left or the right side), as quickly and as accurately as possible. The dot-probe appeared on the left and right an equal number of times. If the dot-probe appeared on the left, then participants pressed the ‘Z’ key on a Microsoft 400 qwerty-type keyboard, whereas if the probe appeared on the right, then they pressed the ‘M’ key. The dot-probe remained on the screen until a response was made, or for 2000 msec. After this

point, a blank screen was displayed for 1000 msec, and then the next trial began. RT and accuracy were recorded for each trial.

Participants received a total of 10 practice and 960 experimental trials. These trials were blocked according to the duration the image pairs were presented for. One block of trials presented images for 150 msec, whereas the other block presented the images for 1250 msec. Each block comprised of an initial set of 5 practice trials, and then 480 experimental trials. The order in which these blocks were presented was counterbalanced according to participant number. We chose to block the trials, rather than randomize the presentation duration, in order to allow for a comparison with similar investigations we have conducted in parallel to this study. Whilst dot-probe studies often randomise different durations, blocking is also utilized (Hunt et al., 2006; 2007; Keogh et al., 2003; Macleod and Rutherford 1992).

Each block of trials contained 96 unique presentation trials, which were all presented 5 times. These 96 trials comprised of 8 actors (4 males and 4 females), each containing 3 different image pair combinations (pain/neutral, fear/neutral, neutral/neutral) i.e., 8 x 3 x 2 x 2 = 96 trials. For the pain and fear image pairs, each target-neutral pair appeared in two different orientations, with the target expression appearing on either the left or the right an equal number of times (i.e. pain/neutral, neutral/pain, fear/neutral, neutral/fear). Since the neutral/neutral pairs contained the same image, expression location was not relevant in these trials. The probe location was balanced across the target pairs an equal number of times.

We acknowledge that we have a larger number of trials than is typically found for studies of this type, and that boredom and/or fatigue could be a factor in this study design. The larger number of trials was due to the need for an adequate number of possible responses per cell of the study, combined with the additional

number of within-groups factors that we were interested in (sex of actor; presentation duration). In order to counter the effects of fatigue, we allowed for two evenly spaced rest breaks within each block of trials. Also, within each block of trials, the presentation of images was randomised. These controls with the experimental design should mean that whilst we cannot rule out issues associated with fatigue, the effects they had should even out across the study. Given concerns around fatigue, we conducted preliminary analysis to consider this point in more detail (see results).

The image sizes were 7.62 × 7.62 cm, and presented side by side on a 19" LCD screen with a resolution of 1280 × 1024 pixels and a 60 HZ refresh rate. Participants' viewing distance was approximately 60 cm with a visual angle of 3.63° for each image stimulus.

2.5 Procedure

Following approval from the Department of Psychology's Research Ethics Committee, University of Bath, participants were recruited, all of whom provided informed consent to participate in the study. Demographic details were initially collected. Participants were then provided with instructions about the task, and given opportunities for question and clarification. The task was conducted on a computer within individual testing cubicles. The task lasted between 35-40 minutes, after which participants were provided details about the purpose of the study.

3. Results

3.1 Data screening and performance checks

RTs were initially screened, and responses below 200 msec and above 1000 msec were removed as outliers. In addition, total accuracy scores were examined by

calculated standardized (Z) scores for the 150 msec and 1250 msec blocks of trials. Following the recommendations of Tabachnick and Fidell (2005), we defined outliers as standardized accuracy scores values that exceeded ±3.29. This resulted in three individuals being removed, one male due to low accuracy scores in the 150 msec phase, and two females due to low accuracy scores in the 1250 msec phase.

We conducted some initial checks on our data. Although block order was counterbalanced between participants, this was done irrespective of their sex. There were 8 females and 14 males who received the 150 msec trials first, whereas 16 females and 12 males received the 1250 msec trials first. We, therefore, examined whether there was a difference in the proportion of males and females who received the 150 msec block of trials first or second. A 2x2 Chi-square test revealed no significant association between sex and order in which participants completed the blocks of trials (χ^2 (1) = 2.13, p=.17). Any potential order effects associated with block order should therefore have evened out across participants.

As outlined above an additional concern was that within a block of trials, the large number of trials may have resulted in fatigue or boredom. We therefore conducted preliminary analysis on the RT data to check for a decline in performance within each block of trials. We calculated an average RT for the first and second half of trials within each of the presentation blocks. For example, within the 150 msec block, we created the mean RT for the first 240 trials, and for the last 240 trials. We conducted a split-half reliability analysis between these average RTs in the first and second testing phases (e.g., phase 1: 150 msec group mean RT, 1250 msec group mean RT). The Spearman-Brown correlation was .94, indicating good internal consistency across the testing phases.

We also entered the four mean RTs into a mixed-groups ANOVA, with the sex of participant (male vs. female) as a between-groups factor, and presentation time block (150 msec vs. 1250 msec) and trial phase (first vs. second) as within-groups factors. This revealed a significant main effect for trial phase ($F(1, 48)= 7.65$, $p=.01$; $\eta_p^2 = .14$), which showed that responses were slower in the second (mean RT = 360 msec) compared to the first half (mean RT = 353 msec) across the presentation blocks. However, inspection of the means suggests this was only a small decrease in overall performance. In addition, a significant main effect of presentation time was also found, which indicated that responses were generally slower in the 1250 msec block of trials (150 msec block = 336 msec, 1250 msec block = 377 msec; $F(1, 48)= 54.90$, $p=.00$; $\eta_p^2 = .53$). The only other significant effect found was an interaction between presentation time, trial phase and sex of participant ($F(1, 48)= 4.26$, $p=.04$; $\eta_p^2 = .08$). This latter effect was unexpected, and warrants further investigation (Note: non-significant effects for this and subsequent ANOVAs are in supplementary material, ResultsS1).

We therefore split the sample between male and female participants, and repeated the ANOVA for each group, but this failed to reveal a significant presentation time by trial phase interaction for either. Splitting the sample by the other factors involved in this interaction also failed to reveal the location of the significant difference. Although we could not locate the source of the interaction effect, what it suggested is that performance within a block of trials may change, and should be considered in the subsequent analysis, and interpretation.

In light of this, we conducted two additional analyses. First, a split-half reliability analysis on the attentional bias indexes, to see whether they were

consistent across the first and second half of trials. Reliability was very low (Spearman-Brown coefficient = .25), suggesting that biases may vary according to the phase of testing. Interestingly, when Green et al. (2016) examined the general internal reliability of Stroop interference effects, they also found raw RTs were reliable, whereas indexes had low reliability. Second, we repeated each of the analysis reported below (attentional bias index, congruency index, incongruency index), with the two phases (first, second phase within a block) as an additional within-groups factor. This did not reveal any significant effects, and did not alter the pattern of results. Therefore, whilst there may be issues around index reliability, and general performance may have declined slightly within a block of trials, this did not seem to result in any overall differences in the bias-related effects found. We only report the core analyses in the following sections.

3.2. Calculations of bias indexes

In order to examine selective attentional biases, a series of indexes were calculated. First, congruent RT scores were created for each male and female expression type, by calculating averages from responses where dot-probes appeared in the same location as the pain- and fear-related target expression. A set of incongruent RT scores were then calculated from responses where dot-probes appeared in a different location from the target expression. Attentional bias indexes (Brookes et al., 2017; Keogh et al., 2001; Macleod et al., 1986) were calculated by taking the congruent RT scores away from the incongruent RT scores (RTincong – RTcong); positive values indicate a relative bias towards the target expression, whereas negative scores are taken as indicative of attentional avoidance.

To establish whether there was a vigilance or disengagement bias, we followed the same procedures as described by Brooks et al. (2017). Pain vigilance was examined by creating a congruency index. For this index, the average RT for the neutral/neutral trials was taken away from the average responses to the congruent trials (RTcong – RTneutral). This was conducted separately for each type of expression-pair type (pain, fear) and sex of actor (male, female). For pain vigilance, we would expect to see a negative value congruency index at the faster presentation durations, as this reflects faster responses for pain/neutral expression pairs compared to neutral/neutral trials. Avoidance would be indicated by a positive congruency index.

Disengagement was examined by creating an incongruency index. Here the average neutral/neutral trial responses were taken away from the average incongruent trials (RTincong – RTneutral). A positive incongruency index score during the later presentation duration condition is taken to reflect a problem with disengagement, as this would be due to responses being slower when presented with pain/neutral pairs compared to neutral/neutral pairs. A negative incongruency index score would reflect a greater ability to disengage from target expressions.

Means and standard deviations of the averaged attentional bias, congruency and incongruency indexes can be viewed in Tables 1-3.

Tables 1-3

3.3 Attentional bias index

The first analyses were conducted on the attentional bias indexes. A series of one sample t-tests were initially performed for each of the bias indexes (Baum et al.,

2013), with a reference point of 0 (see Table 1). The only significant effect found was for the male pain expressions presented at 150 msec (t(49) = 2.03, p=.048). This pointed towards a possible increase in attentional orientation to male expressions of pain when presented at shorter durations.

A mixed-groups ANOVA on the attentional bias indexes was conducted to confirm this, with sex of participant (male vs. female) as the between-groups factor, and presentation duration (150 vs. 1250 msec), sex of actor (male vs. female), and expression type (fear vs. pain) as within-groups factors. The ANOVA revealed no significant effects. This indicated that there were no sex-related differences in attentional biases toward facial expressions of pain or fear.

3.4 Congruency index

The next set of analyses were conducted on the congruency indexes. One-sample t-tests (see Table 2) indicate one significant effect, for female pain expressions presented at 150 msec. The positive value suggests an avoidance of female expressions of pain.

In the main ANOVA, no significant main effects, or significant 2-way interactions were found. A significant 3-way interaction was, however, found between presentation duration, sex of actor and expression-pair type (F(1, 48)= 6.56, p=.01; η_p^2 = .12), as well as a significant 4-way interaction, which included the sex of participant (F(1, 48)= 5.25, p=.03; η_p^2 = .10). In order to understand these complex interactions, we conducted two separate ANOVA's, one on the 150 msec presentation time block of trials, and one on the 1250 msec blocked trials. Increased vigilance to pain would be reflected in a negative congruency index at the early presentation phase.

For the early presentation condition, a significant 2-way interaction was found between sex of actor and expression-pair type (F(1, 48)= 8.54, p=.005; η_p^2 = .15; see Figure 1). No other significant main or interaction effects were found. In order to understand the nature of this interaction, we conducted a series of post-hoc simple effects tests on the 150 msec congruency indexes to examine (1) the effect of sex of actor on the two expression indexes, and (2) whether expression type affected male and female expression indexes. To control for Type I errors, we applied a Bonferroni correction, so that the adjusted alpha value for significance was set at .05/4 comparisons = p<.0125. No significant differences at the adjusted level were found between the pain and fear indexes when viewing male (F(1, 48) = 3.03, p=.09; η_p^2 = .06) or female expressions (F(1, 48) = 5.97, p=.018; η_p^2 = .11). When examining within each expression index, however, sex of actor had a significant effect on the pain face congruency index (F(1, 48) = 6.90, p=.01; η_p^2 = .13), but not on the fear expression congruency index (F(1, 48) = .06, p=.82; η_p^2 = .00). A negative congruency index score was found for male pain faces (mean = -1.82, SD = 16.94), compared to the more positive score for female pain faces (mean = 5.12, SD = 17.86). This suggests that increased early vigilance towards pain when displayed by males, with a relative avoidance of pain expressions by females. This is consistent with the one-sample t-test reported at the start of this section.

Although we did not predict pain-related vigilance at later stages of attention (1250 msec condition), given the 4-way interaction with sex of participant, we examined the later presentation indexes in a further ANOVA. No significant effects were found. We therefore conducted further exploratory analysis, separating by sex of participant. This indicated a significant 2-way interaction between expression-pair

type and sex of actor within male (F(1, 48) = 7.38, p=.01; η_p^2 = .23), but not female observers (F(1, 48) = .28, p=.61; η_p^2 = .01).

Follow-up simple effects tests (with adjusted alpha set at .05/4 comparisons = .0125) were conducted on the 1250 msec responses amongst the male participants. No difference between pain and fear expression indexes was found when actors were either male (F(1, 48) = 2.90, p=.10; η_p^2 = .06) or female (F(1, 48) = 1.99, p=.17; η_p^2 = .04). The effect of actor sex was not found to have a significant effect at the adjusted level on either fear (F(1, 48) = .36, p=.55; η_p^2 = .01) or pain expression indexes (F(1, 48) = 3.90, p=.05; η_p^2 = .08). However, as can be seen from the exact significance levels, the effect of actor sex on pain expressions is the likely reason for this interaction. Means suggested that at later presentation stages, male participants show the opposite effect to that found in early phases -- in that a relative avoidance of male expressions of pain (mean = 6.98, SD = 16.98) was found compared to greater vigilance towards female pain expressions (mean = -4.90, SD = 20.08).

Figure 1 here

3.5 Incongruency index

For the incongruency, index one-sample t-tests (see Table 3) did not show any significant effects. The main ANOVA revealed one significant effect, which was an interaction between the sex of the participant and expression type (F(1, 48)= 7.13, p=.01; η_p^2 = .13). No effect was found involving presentation duration, despite predictions that a disengagement effect would be found at later presentation phases for the incongruency index.

Simple effects tests were conducted on the significant two-way interaction between the sex of the participant and expression index type (see Figure 2). As before, a Bonferroni-type correction was applied to these post-hoc tests ($p<.0125$). This analysis failed to reveal any significant differences at the adjusted level, however. There was no significant effect of expression type within male ($F(1, 48)= 3.96$, $p=.05$; $\eta_p^2 = .08$) or female participants ($F(1, 48)= 3.21$, $p=.08$; $\eta_p^2 = .06$). Similarly, there was no significant effect of the sex of participant on either fear ($F(1, 48)= .83$, $p=.37$; $\eta_p^2 = .02$) or pain incongruency indexes ($F(1, 48)= 4.95$, $p=.03$; $\eta_p^2 = .09$). Although no significant effects were found, inspection of Figure 2 confirms the presence of crossover interaction. In the case of crossover interactions, it is plausible for simple effects test to be non-significant. The difference in means in one condition is positive and the other negative i.e., a reversal of effect across groups. For females, there was a relative difficulty in disengaging from pain expressions, whereas males were less likely to disengage from fear.

Since some question whether we should include the faster presentation durations in an analysis on disengagement (Baum et al., 2013), the main analysis was repeated on just the later incongruency index. The sex of participant by expression type interaction remained significant ($F(1, 48)= 4.45$, $p=.04$; $\eta_p^2 = .09$).

Figure 2 here

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4. Discussion

This study found sex-related effects in the detection of facial expressions of pain, and confirmed the utility in using an objective measure of selective attention to

study pain communication. However, effects seemed related more clearly to the sex of the actor, than the sex of observer. Also, rather than a general attentional bias to pain, detection differences only became apparent when focusing on the specific attentional processes thought to be involved, namely, vigilance and disengagement.

The lack of observer sex differences in attentional biases towards both pain and fear-related expressions was surprising given previous studies suggest that women may have a stronger threat bias (Pfabigan et al., 2014; Tran et al., 2013). It is possible that the sample size was simply not large enough to detect relatively small attentional bias differences between men and women. Indeed, attentional bias effects across pain groups can be small, and the current study may well have been underpowered (Crombez et al., 2013). Alternatively, it may be that sex-related attentional biases are not as general in nature as we had thought, and are only found in subgroups, such as amongst those currently in pain or with a particularly high fear of pain (Crombez et al., 2013; Schafer et al., 2016). Greater pain sensitivity and interpretative biases are more apparent amongst females with high levels of anxiety (Keogh and Birkby 1999; Keogh et al., 2004). We did not measure fear of pain or anxiety, so future studies could consider whether these negative constructs moderate any effects that observer sex has on the attentional processing of pain expressions. It would also be interesting to clarify whether observer sex-related bias effects are due to differences in anxiety, or if some anxiety-related biases are linked to sex-related factors. This latter is rarely considered in attentional bias studies on pain, as sex and gender are not directly considered, despite established male-female differences in pain (Fillingim et al., 2009).

Although we did not find a general attentional bias effect, focusing on the processes involved could still reveal interesting patterns. Indeed, Brookes et al.

(2017) also failed to find evidence for an overall attentional bias toward pain, but reported differences when separating vigilance/avoidance effects from those linked to disengagement. When we did this in the current study, differences emerged. For the congruency indexes, we found an early avoidance of female expressions of pain. Here, sex of actor, rather than sex of observer, was the key. However, when we examined the later phase of attention (1250 msec trials), both the sex of participant and actor were relevant. However, the nature of this effect was difficult to isolate.

The key finding, for early avoidance of female expressions of pain, is interesting in light of previous research. Our study was informed by work into anxiety biases, where we would have expected to see vigilance towards threat, including pain (Carr et al., 2016; Pintzinger et al., 2016; Prkachin et al., 2004). It was unclear why we failed to find similar sex-related biases for fearful expressions. Even so, there are related findings reported by Riva et al. (2011) who found that both male and female participants were slower at detecting painful expressions displayed by women. Such slowing could be due to an initial attentional avoidance of female expressions of pain. If this avoidance of pain expressions translates to the clinic, it would be intriguing to consider whether this affects how pain is judged, and if it contributes to an under-detection of female pain. If so, it suggests a need to train observers, especially carers, to be more vigilant of pain expressions.

The current study also considered sex differences in the disengagement of attention from pain-related expressions. When exploring the incongruency indexes we found the anticipated sex of participant effect, in that females seemed to exhibit slower disengagement from pain-related expressions when compared to men. We need to be somewhat cautious about this interpretation as the follow-up analysis was not statistically significant, and interpretation based on viewing a crossover

interaction. It was also unclear why this disengagement effect was not limited to the later presentation times (Baum et al., 2013), or why it did not occur for fear. This could suggest something specific about pain, in that once attended to, women maintained their attention on facial expressions of pain. Alternatively, it could be that viewing pain in another person promotes a rapid withdrawal of attention by male observers. These explanations are speculative, and further consideration into why such differences occur is required.

There are some methodological considerations. The current study utilized static expressions of pain displayed by actors. As with all carefully controlled basic experimental methodologies, we need to be mindful of issues around translation and seek to establish whether similar effects occur in real world settings. There are also design choices that could have affected our results e.g., a large number of trials, sample size, fatigue etc. For example, we choose to block the two presentation conditions rather than randomise trial order throughout. Whilst blocking and randomization presentation times have been previously used in dot-probe studies (Brookes et al., 2017; Keogh et al., 2003), there is related evidence that blocking trials, around semantic relatedness, can affect outcomes (Cox et al., in press; Holle et al., 1997). Future research should empirically test whether blocking affects reliability. Other aspects around the temporal nature of such biases, and the extent to which performance changes across a task should be considered (Waters et al., 2005; Zvielli et al., 2014).

Another issue to deliberate is our choice to pair target expressions with neutral images from the same actor – our rationale was to carefully control the identity of actors in image pairs. This meant the neutral images were displayed more often that pain and fear expressions, and so it is possible that the relative novelty of

the pain and fear expressions could have resulted in a bias, or changed the nature of the effect. There are two reasons why we do not think this to be the case. First, the novelty bias should be similar for fear and pain expressions, whereas we found differences between the two. Second, a novelty bias would result in all responses to congruent trials to be shorter than incongruent trials, leading to the attentional bias index being consistently positive. This was not the case. Whilst we cannot definitively rule out “novelty” of target expressions as a factor, we are confident that our findings are not due to the different occurrences of neutral expressions.

In terms of future directions, it would be interesting to see whether similar pain-related avoidance effects occur for other expressions such as anger and sadness, or positive expressions. Similarly, we focused on attention to facial expressions, yet there are other channels of expression communication, including through bodily posture. It would be useful to know whether there are similar sex-related detection biases when viewing pain communicated through the body. There is also a need to carefully consider the gendered context of pain, and in particular whether sex and gender is important in communicating pain. Rarely are sex-related effects considered when looking at cognitive biases in pain, yet the current findings suggest this is relevant, especially when viewing male and female expressions. Studies are emerging that consider sex-related factors in various dyadic interpersonal interactions around pain (Boerner et al., 2017; Edwards et al., 2017; Newton-John and Williams 2006). Our results suggest that initial attentional processes are relevant also, and there is a need to see how they might affect how men and women understand, interpret and potentially respond to the pain of others. Future research should include sex as a factor, as routine.

The current findings have potential implications for those interested in sex and gender difference in pain. There is merit in considering the role interpersonal factors have in understanding how men and women communicate pain, including how it is detected and responded to. There is utility in thinking beyond simple pain recognition approaches, and that attention, memory and interpretation of pain behaviours warrant further investigation. There is preliminary work around judgements about expressions, suggesting male and female pain expressions are differentially judged, which in turn can affect treatment decisions (Hirsh et al., 2009; Schafer et al., 2016). Attentional biases could be further investigated amongst carers (Mohammadi et al., 2012), who routinely come in contact with, and respond to expressions of pain. It may be that initial detection differences in how pain is viewed may also lead to different carer behaviours.

In sum, the current study confirms that there is utility in investigating sex-related effects in the initial detection of pain-related expressions. The dot-probe task allows a more refined and precise investigation of attentional mechanisms, as well as allow for the generation of potentially interesting questions around whether there are sex-related biases in how we detect and understand the pain of others. This study provides initial proof of concept that attentional factors are relevant to how men and women communicate pain, and demonstrates a need to understand the precise cognitive processes that are involved.

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The authors have no known conflicts of interest associated with this work. EK has received unrelated research grants from Reckitt Benckiser Healthcare (UK) Limited, and provided unrelated consultancy services to RB UK Commercial Ltd.

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6. Author contribution

EK conceptualised the study, led the analysis, interpreted the results and wrote the manuscript. FC collected the data, contributed to the interpretation of findings and commented on the draft manuscript. SW helped design the study, developed the computer programme, led data file preparation, contributed to the interpretation of findings and commented on the draft manuscript.

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Figure captions

Figure 1: Effect of sex of actor and type of expression on congruence index scores during the early presentation phase (150msec). (± standard error of mean)

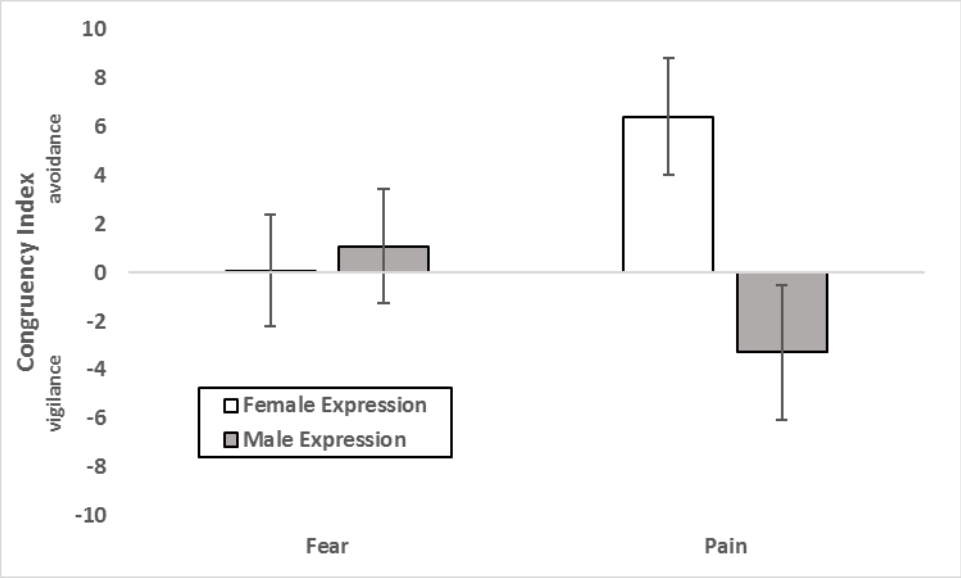

Figure 2: Effect of sex of participant and type of expression on incongruence index scores. (± standard error of mean)

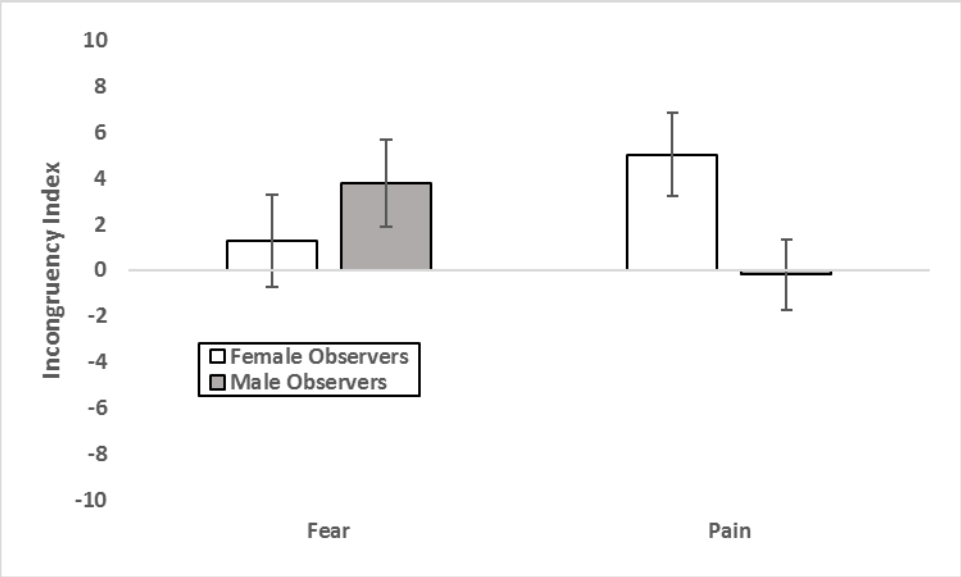

Table 1: Mean (and SD in parenthesis) attentional bias index for male and female participants, by presentation time, sex of actor, and expression type. Overall means and one-sample tests also included.

		Males		Females		Overall Mean		One-sample t-test
150 msec	Female Fear Index	6.65	(17.88)	-2.09	(22.79)	2.46	(20.65)	.84
	Female Pain Index	-3.32	(15.85)	-0.20	(18.24)	-1.82	(16.94)	-.76
	Male Fear Index	2.38	(15.87)	1.12	(18.15)	1.78	(16.84)	.75
	Male Pain Index	5.74	(16.05)	4.44	(19.96)	5.12	(17.86)	2.03*
1250 msec	Female Fear Index	1.84	(19.83)	5.53	(22.24)	3.61	(20.89)	1.22
	Female Pain Index	-0.37	(23.34)	2.18	(23.92)	.85	(23.41)	.26
	Male Fear Index	5.64	(25.22)	1.61	(24.43)	3.70	(24.67)	1.06
	Male Pain Index	-1.74	(16.94)	2.82	(25.80)	.45	(21.54)	.15

Note: * $p<.05$

Table 2: Mean (and SD in parenthesis) congruency bias index for male and female participants, by presentation time, sex of actor, and expression type. Overall means and one-sample tests also included.

		Males		Females		Overall Mean		One-sample t-test
150 msec	Female Fear Index	-3.84	(14.32)	4.33	(17.55)	.08	(16.32)	.03
	Female Pain Index	4.37	(17.61)	8.62	(16.31)	6.41	(16.96)	2.67*
	Male Fear Index	3.29	(17.41)	-1.31	(15.60)	1.08	(16.56)	.46
	Male Pain Index	-3.57	(16.97)	-2.96	(22.43)	-3.28	(19.58)	-1.18
1250 msec	Female Fear Index	1.14	(20.08)	-2.43	(16.04)	-.57	(18.16)	-.22
	Female Pain Index	-4.90	(20.43)	5.64	(20.15)	.16	(20.78)	.06
	Male Fear Index	-1.89	(19.36)	-1.67	(19.07)	-1.78	(19.02)	-.66
	Male Pain Index	6.98	(16.98)	2.12	(22.66)	4.65	(19.85)	1.66

Note: * $p<.05$

Table 3: Mean (and SD in parenthesis) incongruency bias index for male and female participants, by presentation time, sex of actor, and expression type. Overall means and one-sample tests also included.

		Males		Females		Overall Mean		One-sample t-test
150 msec	Female Fear Index	2.81	(12.30)	2.24	(14.95)	2.54	(13.50)	1.33
	Female Pain Index	1.06	(11.95)	8.42	(22.09)	4.59	(17.77)	1.83
	Male Fear Index	5.67	(16.96)	-0.18	(18.48)	2.86	(17.77)	1.14
	Male Pain Index	2.16	(13.85)	1.49	(15.60)	1.84	(14.56)	.89
1250 msec	Female Fear Index	2.98	(19.92)	3.11	(23.14)	3.04	(21.31)	1.01
	Female Pain Index	-5.27	(16.69)	7.83	(17.55)	1.01	(18.18)	.96
	Male Fear Index	3.75	(16.02)	-0.06	(22.26)	1.92	(19.16)	.71
	Male Pain Index	1.23	(16.83)	2.39	(19.86)	1.79	(18.17)	.70

Note: * $p<.05$

Supplementary Material (ResultsS1)

Non-significant effects

1. Data screening and performance checks (ANOVA on Mean RTs)

Non-significant main effects: sex of participant ($F(1, 48)= 3.22$, $p=.08$);

Non-significant 2-way interactions: trial phase by sex of participant ($F(1, 48)= .00$, $p=.95$), presentation time by sex of participant ($F(1, 48)= .00$, $p=.95$), presentation time by trial phase ($F(1, 48)= .07$, $p=.80$).

2. Attentional bias index analysis

Non-significant main effects: sex of participant ($F(1, 48)= .01$, $p=.94$), presentation duration ($F(1, 48)= .02$, $p=.88$), sex of actor ($F(1, 48)= .92$, $p=.34$), expression type ($F(1, 48)= .73$, $p=.40$);

Non-significant 2-way interactions: presentation time by sex of participant ($F(1, 48)= .64$, $p=.43$), expression type by sex of participant ($F(1, 48)= 1.58$, $p=.21$), sex of action by sex of participant ($F(1, 48)= .05$, $p=.83$), presentation time by expression type ($F(1, 48)= .36$, $p=.55$), presentation time by sex of actor ($F(1, 48)= .47$, $p=.49$), expression type by sex of actor ($F(1, 48)= .87$, $p=.36$);

Non-significant 3-way and 4-way interactions: presentation time by expression type by sex of participant ($F(1, 48)= .06$, $p=.81$), presentation time by sex of actor by sex of participant ($F(1, 48)= .21$, $p=.65$), sex of actor by expression type by sex of participant ($F(1, 48)= .02$, $p=.89$), presentation time by sex of actor by expression type ($F(1, 48)= 1.32$, $p=.26$); presentation time by expression type by sex of actor by sex of participant ($F(1, 48)= 2.62$, $p=.11$).

3. Congruency index analysis

Non-significant main effects: sex of participant ($F(1, 48)= .40$, $p=.53$), presentation duration ($F(1, 48)= .06$, $p=.81$), sex of actor ($F(1, 48)= .50$, $p=.48$), expression type ($F(1, 48)= 2.52$, $p=.12$);

Non-significant 2-way interactions: presentation time by sex of participant ($F(1, 48)= .14$, $p=.71$), expression type by sex of participant ($F(1, 48)= .77$, $p=.39$), sex of actor by sex of participant ($F(1, 48)= 2.76$, $p=.10$), presentation time by expression type ($F(1, 48)= .77$, $p=.39$), presentation time by sex of actor ($F(1, 48)= 1.80$, $p=.19$), expression type by sex of actor ($F(1, 48)= .78$, $p=.38$);

Non-significant 3-way and 4-way interactions: presentation time by expression type by sex of participant ($F(1, 48)= .40$, $p=.53$); presentation time by sex of actor by sex of participant ($F(1, 48)= .07$, $p=.79$), sex of actor by expression type by sex of participant ($F(1, 48)= .73$, $p=.40$).

4. Incongruency index analysis

Non-significant main effects: sex of participant ($F(1, 48)= .41$, $p=.53$), presentation duration ($F(1, 48)= .26$, $p=.61$), sex of actor ($F(1, 48)= .17$, $p=.69$), expression type ($F(1, 48)= .01$, $p=.93$);

Non-significant 2-way interactions: presentation time by sex of participant ($F(1, 48)= .47$, $p=.49$), sex of actor by sex of participant ($F(1, 48)= 3.15$, $p=.08$), presentation time by expression type ($F(1, 48)= .24$, $p=.63$), presentation time by sex of actor ($F(1, 48)= .06$, $p=.81$), sex of actor by expression type ($F(1, 48)= .08$, $p=.77$).

Non-significant 3-way and 4-way interactions: presentation time by expression type by sex of participant ($F(1, 48)= .14$, $p=.71$); presentation time by sex of actor by sex of participant ($F(1, 48)= .02$, $p=.88$), sex of actor by expression type by sex of participant ($F(1, 48)= 1.23$, $p=.27$), presentation time by sex of actor by expression type ($F(1, 48)= .76$, $p=.39$), presentation time by sex of actor by expression type by sex of participant ($F(1, 48)= .22$, $p=.64$).