DOI:
10.1002/ejp.1072

Publication date:
2017

Sex differences in the decoding of pain-related body postures

Joseph Walsh [1]*, Christopher Eccleston [2,3], Edmund Keogh [2]

[1] Department of Psychology, Bath Spa University

[2] Centre for Pain Research, University of Bath, United Kingdom

[3] Department of Clinical and Health Psychology, Ghent University, Belgium

*Corresponding author: Joseph Walsh, Bath Spa University, Newton St Loe, Bath, BS29BN, United Kingdom, email: j.walsh2@bathspa.ac.uk

Submission category: Original article

Funding Source: The lead author was funded by a Graduate School Scholarship provided by the University of Bath.

Declarations and conflict of interest disclosure: The work described in this manuscript was conducted as part of a PhD thesis by Joseph Walsh at the University of Bath.

Running head: Sex differences in the decoding of pain-related body postures

'What does this study add?': Observer's judgements of pain displayed through body postures are driven on the sex of the person in pain.

Sex differences in the decoding of pain-related body postures

Abstract

Pain can be detected through nonverbal cues, including facial expressions, vocalisations, and body posture. Whilst there are sex differences in how emotional expressions are recognised, these differences have not always been found for pain. One reason for this inconsistency may be methodological, as pain studies tend not to be designed to investigate individual differences in expression recognition. Also, few studies consider sex differences outside facial expression. This study applied an image degradation method used to examine individual differences in emotion recognition, to investigate sex differences in the decoding of pain body postures. Forty participants (20 male) were presented with a series of body posture images depicting pain at differing levels of image degradation. Happiness, anger and sadness expressions were also included for comparison. Results showed significant effects of image degradation, affect type, and actor sex. Females were rated as presenting more intense pain than males; this pattern was also found for fear, but not anger or happiness. The accuracy of pain intensity judgments was reduced as image clarity decreased. Male actors depicting pain were recognised with greater accuracy than female actors. Interestingly, similar patterns were found for anger and fear expressions. We conclude that sex has a significant influence on pain decoding under certain conditions, and whilst there are similarities with the way pain and core emotions are decoded, this may depend on the type of emotion presented. This also suggests that sex-related effects in the recognition of pain expressions may include body postural cues.

Sex differences in the decoding of pain-related body postures

1. Background

There are sex and gender differences in pain, with biological and psychosocial factors thought to play a role (Fillingim et al, 2009, Keogh, 2012, Racine et al 2012a, Racine et al 2012b). Increasingly, interest has turned to social influences, with suggestions that pain occurs in a gendered context, and the specific ways in which males and females interact and communicate pain are important (Keogh, 2014, 2015).

Pain can be communicated through verbal and nonverbal channels, which function to signal threat/harm and elicit protective behaviours in others (Williams, 2002, Craig, 2009). Nonverbal channels include the face (Craig, 1992, Prkachin and Soloman, 2008, Simon et al, 2008), voice (Friedlander, 2006, Belin et al, 2008), and body (Aviezer et al, 2012, Walsh et al, 2014), although most research focuses on facial expressions. Given there are sex differences in the nonverbal encoding and decoding of emotional expressions (Rahman et al, 2004, Hampson et al, 2006, Collignon et al, 2008, McBain et al, 2009, Collignon et al, 2010, Hoffman et al, 2010), male-female differences are expected to exist in how pain is communicated. It is surprising therefore to discover that investigation into male-female variation in nonverbal pain communication has produced equivocal results (Keogh, 2014).

One reason why sex differences show this inconsistent effect could be because they simply do not exist. However, most studies have focused on facial expressions, and few have considered sex differences in the context of vocal or body expressions of pain. Sex may be relevant in other channels of pain communication. An alternative explanation could be methodological – in that studies tend not to be designed with individual differences in mind. For example, Matsumoto (2000) notes that expression recognition research often makes use of highly recognisable stimuli, which can create ceiling effects in recognition accuracy, and in turn inhibit the detection of more subtle individual differences. Pain expression studies also suffer from this problem: they are not designed to detect potentially subtle differences (Simon et al, 2008, Walsh et al, 2014). We therefore sought to consider both possibilities.

In this study we examine sex differences in the perception of expressions of pain and emotions. We consider pain decoding through a different nonverbal channel to that typically investigated – namely body postures. Like the face, the body is considered a key communication channel for pain, in both clinical and experimental studies (Prkachin et al, 2007, Aviezer et al, 2012). We apply a technique used in emotion perception studies to reduce the image clarity of our stimulus set (Wallbott, 1992). Manipulating image clarity allows greater ambiguity, increases task difficulty, and avoids ceiling effects. Since there seems to be a general female superiority in the perception of emotional expressions (McClure, 2000, Becker et al, 2007, McBain et al, 2009), a female (participant) perceptual superiority effect was predicted, especially when the task was made more difficult. We also predicted that females would be rated as having more intense pain than males, with a similar difference predicted for non-pain expressions.

2. Methods

2.1 Participants

40 participants (20 male, average age 26.4 years) were recruited from the University of Bath staff and student population. All had normal or corrected to normal

vision, and provided fully informed consent for their participation in the research. Participants were compensated £5 for their time. All were free of any pain, and had no prior formal training in pain recognition.

2.2 Images of body expression

The Bath Emotion and Pain Posture stimuli (BEPPS) were used in the present study (Walsh et al, 2014). The BEPPS is a stimulus set of 144 two-second dynamic communicative body posture stimuli presenting seven affective expressions (pain, anger, happiness, fear, surprise, disgust, and sadness) and neutral postures. Previous validation work has shown that stimuli are recognised with a high degree of accuracy and specificity (Walsh *et al*, 2014).

In order to control for the ceiling effects in emotion recognition studies Matsumoto et al (1990) suggested the image clarity of stimuli be reduced e.g., by modifying the size or quality (resolution) of the image. Image modification was chosen because it has been successfully used to adapt dynamic facial expression stimuli for individual differences research (Wallbott, 1992). Using Adobe Premiere we applied an image clarity manipulation to the original stimuli. Three levels of reduced clarity were used. Clarity was based on the resolution of the image - clear images were presented at a resolution of 900X900 pixels, the first level of clarity was presented at a resolution of 600X600, and the final level of image degradation was presented at a resolution of 300X300. Accordingly, we refer to the levels as 100% clarity, 66% clarity, and 33% clarity. Figure 1 presents an example of one male and one female stimulus at each level of clarity.

Figure 1 here

2.3 Expression intensity judgement task

Participants were presented with stimuli designed to communicate four target expressions (pain, anger, fear, and happiness). Fear and anger were chosen alongside pain as previous evidence has demonstrated similarities in perception of body postures communicating pain and these expressions (Walsh *et al*, 2014), whilst happiness was chosen as an opposite-valence comparison expression. For each target expression, 16 actors (8 male, 8 female) were selected from the original BEPPS dynamic stimulus set, resulting in 64 different videos. These images were subsequently presented in three different viewing conditions: 100 % clarity, 66% clarity, and 33% clarity. Therefore, participants were presented with a total of 192 images.

For each trial, participants were presented with a fixation cross (+) for 500ms. This was followed by the presentation of the stimulus expression for 2000ms, which is the length of each dynamic stimulus. Stimuli were presented in a pseudo-random order, in which no two stimuli communicating the same target expression could be presented sequentially. Participants' responses were similar to those taken by Simon et al (2008) and Walsh et al (2014). After each stimulus presentation participants were asked to rate the intensity of expression present within the stimulus on a Likert scale of 1 (none at all) to 7 (very intense) for each of the possible four expressions e.g., pain images were rated for their anger, fear, happiness, and pain intensity levels. These intensity ratings were then used to calculate intensity accuracy (hit) rates, as described in Section 2.5. There was no time constraint given for making these responses. Once participants had made a response the next trial image was presented.

2.4 Procedure

After ethical approval had been granted by the University of Bath, participants provided signed informed consent and completed the judgement task. The task was designed using Eprime 2.0. Participants sat at a comfortable distance from a computer monitor and were informed that they would be taking part in a study about emotion recognition. Once they confirmed that they had understood the instructions, the task began. The 192 trials were separated into four equal blocks, and participants were allowed a break between blocks, the length of which was self-determined. On conclusion, participants were debriefed about the nature of the study.

2.5 Analytical strategy

Two analyses were planned, both derived from the judgement intensity scores. One analysis was based on the intensity ratings for each expression, whereas the second was based on how accurate the intensity rating was, and was based on intensity hit rates.

Judgement intensity ratings were analysed using data from the target expression, i.e., pain posture intensity was derived from pain intensity ratings only, and the same for anger, fear, and happiness. Intensity hits (recognition accuracy) was also based on intensity scores, and calculated using this formula:

$$\text{Hit rate} = \frac{N \text{ of correct classification}}{N \text{ of correct classification} + N \text{ of misses}}$$

A correct classification, or ‘hit’, was an instance where the intensity rating for the target expression was greater than the intensity ratings for nontarget expressions, i.e., for each pain expressions, it was a classed a hit if the pain intensity rating was higher than the intensity scores for anger, happiness and fear. An incorrect classification, or “miss”, was an instance where a nontarget intensity rating was higher than or equal to the target expression, i.e., where a pain expression was rated as expressing equal or more anger, fear, or happiness than pain.

For both intensity ratings and intensity hits (judgement accuracy), a 2 (participant sex) X 2 (actor sex) X 4 (expression type: pain, anger, happiness, and fear) X 3 (image clarity level: 100%, 66%, 33%) mixed design ANOVA was conducted. Bonferroni corrected post-hoc *t*-tests were used to examine the nature of specific significant main and interaction effects. This correction was applied separately to each effect, rather than applying a more conservative pooled correction where the adjustment is based upon all comparisons conducted within an ANOVA. Our rationale here was to ensure a balance between Type 1 and Type 2 errors, and to avoid being excessively restrictive in our approach.

3. Results

3.1 Data screening

Data were screened to ensure they met the criteria for parametric testing. First intensity ratings and intensity hits scores were screened for outliers based on the examination of Z-scores - defined as Z-scores that were ±3.29. Analysis was also conducted to examine whether the data were significantly skewed using

Koglomorov-Smirnov tests, which showed no significant skew for either intensity or accuracy data ($p>0.05$).

3.2 Confusion matrix of accuracy and intensity results

Table 1 presents a confusion matrix of mean average intensity ratings for each target expression, separated by actor sex and image clarity. A higher rating for a non-target expression indicates greater confusion. Pain was most frequently confused with fear, and to some extent anger. This confusion is likely to do with the configural similarities between pain and fear body postures, as described by Walsh *et al* (2014). Confusion with happiness expressions was low.

Table 1 here

3.3 Intensity rating analysis

Descriptive statistics for intensity rating data for males and females are provided in Table 2.

Table 2 here

Analysis revealed a significant main effect of image clarity ($F(2,76)= 19.92$, $p<0.05$). Post-hoc analyses using a Bonferroni-corrected p value of 0.017 (0.05/3) showed decreased image clarity was associated with reduced intensity ratings: intensity ratings was higher for 100% clarity compared to 33% clarity ($t(39)= 5.20$, $p<0.017$), and higher for 66% compared to 33% clarity ($t(39)= 6.24$, $p<0.017$).

A significant interaction was found between expression type and image clarity ($F(6,228)= 8.11$, $p<0.05$; see Figure 2). Post-hoc *t*-tests (corrected p value of 0.008, based on 0.05/6) revealed that pain intensity ratings (100 vs. 33 % and 66 vs. 33%)

and fear intensity ratings (100 vs. 66%, 100 vs. 33%, and 66 vs. 33%) significantly declined as image clarity reduced (all at $p<0.008$). In contrast, no difference in intensity ratings was found at any stage of image clarity degradation for happiness and anger expressions, suggesting that the decline in pain intensity rating was similar to fear, but not to all types of expression.

A significant interaction was also found between expression type and actor sex ($F(3,114)= 13.56$, $p<0.05$; see Figure 3). Intensity ratings were higher for females when communicating pain, fear, and anger (corrected p value of 0.05/8 = 0.006. For happiness, males were rated as more intense ($p<0.006$). This is illustrated in Figure 3.

Figures 2 & 3 here

3.3 Intensity hits

Table 3 presents the mean intensity recognition hit rates for each target expression.

Table 3 here

Analysis revealed a significant main effect of expression type ($F(3,114)= 7.36$, $p<0.05$). Pain was recognised with lower accuracy than happiness ($t(39)= 4.10$, $p<0.0125$). A main effect of image clarity was also found ($F(2,76)= 39.43$, $p<0.001$; means: 100%= 7.37, 66%= 7.16, 33%= 6.67). Corrected post-hoc *t*-tests (0.05/3 = 0.017) showed as image clarity decreased, recognition accuracy reduced (33 vs. 66% t=6.90, $p<0.017$; 66 vs 100%, t=2.87, $p<0.017$; 33% vs 100% t=7.89, $p<0.017$). A significant main effect of actor sex ($F(1,38)= 8.76$, $p<0.05$) indicated that male expressions were better recognised (mean accuracy= 7.15) than female expressions (mean accuracy= 6.99).

A significant interaction was found between expression type and actor sex ($F(3,114) = 9.19$, $p<0.05$; see Figure 4). Post-hoc corrected *t*-tests (0.05/8 = 0.006) showed that when presenting pain, male actors were recognised with greater accuracy than female actors ($t(39) = 3.81$, $p<0.006$). A similar pattern was found for fear ($t(39) = 3.91$, $p<0.006$) and anger ($t(39) = 3.96$, $p<0.006$), but not happiness ($t(39) = 2.05$, $p>0.006$).

A significant interaction was found between image clarity and actor sex ($F(2,76) = 3.90$, $p<0.05$; see Figure 5). As before this was further explored using corrected *t*-tests (0.05/8 = $p<0.006$). For female actors, recognition accuracy declined significantly at each stage of image clarity (100 vs. 66%, 66 vs. 33%, $p<0.006$). For males, no difference was found between 100% and 66% accuracy, although accuracy was worse between 66% and 33% clarity ($p<0.006$).

A final significant interaction was found between expression type and image clarity ($F(6,228) = 12.30$, $p<.05$; see Figure 6). Corrected post-hoc *t*-tests (0.05/6 = 0.008) indicated that pain, fear, and anger, accuracy declined significantly at each stage of image degradation. No reduction in recognition accuracy was found at any stage of image clarity degradation for happiness.

Figures 4-6 here

4. Discussion

Using an image clarity manipulation, we successfully investigated sex-related effects on the recognition of pain-related bodily expressions. Small, but significant, differences were found in how observers decoded male and female pain expressions. Female expressions were viewed as being more intense, whereas male expressions were recognised with greater accuracy. These findings extend previous investigations into the effects of sex on the recognition of emotional expressions to include pain (Becker et al, 2007, McBain et al, 2009, Collignon et al, 2010). However, our results also contrast with studies that report failing to find sex differences in pain expression recognition, including at least one that focused on body postures (Prkachin and Solomon, 2008, Simon et al, 2008, Walsh et al, 2014). Here, we have evidence that sex influences pain decoding and judgment. Interestingly, our sex-related effects were only found when expressions were presented under difficult viewing conditions, supporting the view that individual differences in expression decoding may become more apparent when there are higher levels of visual ambiguity (Matsumoto, 1990, Keogh, 2014).

That pain expressions displayed by females were viewed as more intense, whereas male expressions were more easily recognised, is also interesting, especially since accuracy and intensity rates were essentially drawn from the same data. One reason could be linked to stereotypical beliefs and expectations that females are more emotionally expressive when in pain (Robinson *et al*, 2001, Myers *et al*, 2006), and so females are rated as more intense. However, this would not necessarily explain why we also found greater accuracy in recognizing pain in men. However, outside of pain, certain negative expressions, such as anger, can be more readily identified in men (Becker *et al*, 2007). Some have argued that such a male bias may be the result of an evolutionary need to identify danger, such as when away from the family group, which males may have been more likely to engage in (Vigil, 2004).

A second innovation in this study was to investigate sex differences in the perception of body expressions of pain. Pain studies have mostly focused on facial expression, and so less is known about other channels of nonverbal behaviour. It is possible that these sex-related effects are only found when viewing pain-related body postures. However, our previous work using the same pain body postures did not find sex differences (Walsh et al, 2014). One of the key differences between these studies was the manipulation of task difficulty, a method which has not generally been adopted in pain expression research. Although we assume that the sex differences reported here are due to this experimental manipulation, independent replication of this manipulation is needed before firm conclusions are drawn. If this is a real effect, then it would suggests that if sex differences in the perception of nonverbal pain cues do occur, they may vary around the channel of communication adopted. Furthermore, future research must consider what element of body posture and movement is differentiated between males and females. Previous evidence has shown that sex and emotion can be identified using only gait and movement cues from body posture (Troje, 2002), and considering the ambiguity and task difficulty of the 33% condition of this study, it may be that participants are better able to identify males due to gait and movement differences present between males and females. Further research may investigate this further by differentiating postural, movement, and configural cues.

Alongside pain, this study also informs us about more general sex differences in how affective information is recognised in body postures. Similarities were found in the intensity ratings of female body expressions of fear and anger, when compared to pain. Interestingly, the core expression that seemed to be different was happiness, a finding that has also been reported in the general emotional expression literature (Lipp *et al*, 2009). This sex-related difference in the general recognition of male and female expressions is again in keeping with expectations around females being more expressive of emotion (Vigil, 2009), and suggests similarities in the way in which pain and the other expressions are processed.

Three limitations to the use of our findings should be taken into consideration. First, the use of simple, acted stimuli in the study severely limits the extent to which findings can be applied to broader clinical and real world pain settings. Whilst the stimuli themselves are validated (Walsh et al, 2014), and have been found to have a high recognition accuracy, previous evidence has described differences between real and acted expressions for both pain and emotion communication (Russel, 1994, Russel, 2003). Second, the image manipulation effect did not have an impact on ratings for happiness expressions, so discussion of the relevance of the findings to positive affect should be limited. Third, the overall observed sex effects are small in size, as is often the case with this kind of research.

Taking into account these limitations, future research should aim to further explore the differences observed here. The differences found here were observed in a controlled experimental setting using stimuli designed to be recognisable, and a context stripped of affective and motivational context. When considering the application of these differences to real world instances, in particular with regards to clinical settings, the greater complexity of recognition may amplify differences observed in experimental settings. Accordingly, small significant differences such as those observed here may translate to greater differences in the real world where there is greater ambiguity and an affective-motivational context that influences the interpretation. However, this possibility has yet to be explored, and so remains speculative

If there is a consistent sex bias in how male and female pain is perceived through body postures, and this extends beyond the laboratory, then this may impact on the observation of clinical pain. Clinical observational assessment tools often use body posture to ascertain information regarding the pain of nonverbal patients e.g., infants, dementia sufferers (McGrath et al, 1985, Jensen et al, 1999, Herr et al, 2006, Hand et al, 2010). If differences exist in how males and females are recognised and interpreted, then relying solely on observational measures without foreknowledge of communication differences could potentially lead to complications in diagnosis and treatment. Increased ratings of female pain intensity could result in faster diagnosis or prescribing behaviours, thus affecting treatment outcomes. Accordingly, it is important when conducting observational diagnostics that potential biases in how pain is communicated and recognised in body posture may influence results. Bartley and Fillingim (2013) report that sex differences in responsiveness to pain treatments may be due in part to the sex of both patient and clinician. Differences in communication may be in part responsible for this disparity, although this is speculative and significant further evidence is needed before this can be substantiated.

Two immediate implications present themselves for further investigation. First, if sex differences exist in how pain is communicated through body posture, the same may be true for other nonverbal channels, and further research is needed to examine this potentially rich source of information. In particular, this study enhances our understanding of how sex may effect to recognition of pain, and how it is important to explore this fully by examining different channels of communication. Second, examining potential differences in male and female communication of pain in clinical settings is required. Herr (2006) recommends using observational assessment tools in instances where self-report measures are not appropriate, and alongside verbal reporting. In such cases, the extent to which sex differences in postural decoding may bias these judgements is unknown. Although the work presented here is wholly experimental and so cannot be directly applied to clinical practice, it is important that this initial investigation of sex differences in perception is developed in particular in clinical areas where differences might impact on patient care.

In conclusion, we present a study which used a novel methodological technique to examine sex differences in how pain is recognised through body posture. Findings demonstrated that females are viewed as more intense, although the accuracy of intensity ratings may be greater in males. This is consistent with the view that there are sex differences in both emotion perception and pain experience, and highlights the need to carefully consider the methods used for examining for sex differences in how pain decoded through nonverbal behaviour.

Author contributions

Joseph Walsh was responsible for the conception and implementation of the study reported in this article, including data collection and analysis. Joseph Walsh also took the lead in writing the draft. Christopher Eccleston contributed to the conception and design, and provided critical commentary on the interpretation and writing of the paper. Edmund Keogh contributed to the conception and design of the study, supported data analysis and interpretation, and provided critical review and commentary on drafts. All authors discussed core results and commented on the manuscript.

References

Aviezer, H., Trope, Y., Todorov, A. (2012). Body cues, not facial expressions, discriminate between intense positive and negative emotions. *Science* 338, 1225-1229.

Bartley, E., Fillingim, R. (2013). Sex differences in pain: A brief review of clinical and experimental findings. *Br J Anaesth* 111, 52-58.

Becker, D., Kenrick, D., Neuberg, S., Blackwell, K., Smith, D. (2007). The confounded nature of angry men and happy women. *J Pers Soc Psychol* 92, 179-190.

Belin, P., Fillion-Bilodeau, S., Gosselin, F. (2008). The Montreal Affective Voices: A validated set of nonverbal affect bursts for research on auditory affective processing. *Behav Res* 40, 531-539.

Collignon, O., Girard, S., Gosselin, F., Roy, S., Saint-Amour, D., Lassonde, M., Lepore, F. (2008). Audio-visual integration of emotion expression. *Brain Res* 1242,126-135.

Collignon, O., Girard, S., Gosselin, F., Saint-Amour, D., Lepore, F., Lassonde, M. (2010) Women process multisensory emotion expressions more efficiently than men. *Neuropsychologia* 48, 220-225.

Craft, R. (2007). Modulation of pain by estrogens. *Pain* 132, S3-S12.

Craig, K. (1992) The facial expression of pain: better than a thousand words? *APS Journal* 1, 153-162.

Craig, K. (2009). The social communication model of pain. *Canadian Psychology/Psychologie canadiennel* 50, 22-32.

Donges, U., Kersting, A., Suslow, T. (2012) Women's greater ability to perceive happy facial emotion automatically: gender differences in affective priming. *PloS one* 7, e41745.

Fillingim, R., Maixner, W. (1995). Gender differences in the responses to noxious stimuli. *Pain Forum* 4, 209-221.

Fillingim, R., King, C., Ribeiro-Dasilva, M., Rahim-Williams, B., Riley, J. (2009). Sex, gender, and pain: a review of recent clinical and experimental findings. *J Pain* 10, 447-485.

Friedlander, R. (2006) Review of crying as a sign, symptom & a signal. *J Can Acad Child Adolesc Psychiatry* 15, 40, 228.

Hampson, E., van Anders, S., Mullin, L.(2006). *A female advantage in the recognition of emotional facial expressions: Test of an evolutionary hypothesis*, Vol. 27. Netherlands: Elsevier Science, 2006. pp. 401-416.

Hand, I., Noble, L., Geiss, D., Wozniak, L., Hall, C. (2010). COVERS neonatal pain scale: Development and validation. *Int J Peds* 2010, 496719.

Herr, K., Coyne, P., Key, T., Manworren, R., McCaffery, M., Merkel, S., Pelosi-Kelly, J., Wild, L. (2006) Pain assessment in the nonverbal patient: position statement with clinical practice recommendations. *Pain Man Nurs* 7, 44-52.

Hoffmann, H., Kessler, H., Eppel, T., Rukavina, S., Traue, H. (2010). Expression intensity, gender and facial emotion recognition: Women recognize only subtle facial emotions better than men. *Acta psychologica* 135, 278-283.

Jensen, M., Turner, J., Romano, J., Fisher, L. (1999) Comparative reliability and validity of chronic pain intensity measures. *Pain* 83, 157-162.

Keefe, F., Lefebvre, J., Egert, J., Affleck, G., Sullivan, M., Caldwell, D. (2000). The relationship of gender to pain, pain behavior and disability in osteoarthritis patients: The role of catastrophizing. *Pain* 87, 325-334.

Keogh, E. (2012). Sex differences in pain across the life course. In. Moore, R. (2012). *Handbook of pain and palliative care: biobehavioural approaches for the life course*. Springer, New York.

Keogh, E. (2014). Gender differences in the nonverbal communication of pain: A new direction for sex, gender, and pain research? *PAIN* 155, 1927-1931.

Keogh, E. (2015). Men, masculinity, and pain. *PAIN* 156, 2408-2412.

Lipp, O., Price, S. and Tellegen, C. (2009). Emotional faces in neutral crowds: Detecting displays of anger, happiness, an sadness on schematic and photographic images of faces. *Motiv Emot* 33, 249-260.

Matsumoto, D. (1990). Cultural similarities and differences in display rules. *Motiv Emot* 14, 195-214.

Matsumoto, D., LeRoux, J., Wilson-Cohn, C., Raroque, J., Kooken, K., Ekman, P., Yrizarry, N., Loewinger, S., Uchida, H., Yee, A., Amo, L., Goh, A. (2000). A new test to measure emotion recognition ability: Matsumoto and Ekman's Japanese and Caucasian Brief Affect Recognition Test (JACBERT). *J Nonverb Behav* 24, 179-209.

McBain, R., Norton, D., Chen, Y. (2009). Females excel at basic face perception. *Acta psychologica* 130, 168-173.

McClure, E. (2000). A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. *Psychol Bull* 126, 424-453.

McGrath, P., Johnson, G., Goodman, J., Schillinger, J., Dunn, J., Chapman, J. (1985). CHEOPS - a behavioral-scale for rating postoperative pain in children. *Adv Pain Res* 9, 395-402.

Myers, C., Tsao, J., Glover, D., Kim, S., Turk, N., Zeltzer, L. (2006). Sex, gender, and age: Contributions to laboratory pain responding to children and adolescents. *J Pain* 7, 556-564.

Prkachin, K., Schultz, I., Hughes, E. (2007). Pain behavior and the development of pain-related disability: The importance of guarding. *Clin J Pain* 23, 270-277.

Prkachin, K., Solomon, P. (2008). The structure, reliability and validity of pain expression: Evidence from patients with shoulder pain. *Pain* 39, 267-274.

Racine, M., Tousignant-Laflamme, Y., Kloda, L., Dion, D., Dupuis, G., Choinière, M. (2012). A systematic literature review of 10 years of research on sex/gender and experimental pain perception – Part 1: Are there really differences between women and men? *Pain* 153, 602-618.

Racine, M., Tousignant-Laflamme, Y., Kloda, L., Dion, D., Dupuis, G., Choinière, M. (2012). A systematic literature review of 10 years of research on sex/gender and pain perception – Part 2: Do biopsychosocial factors alter pain sensitivity differently in women and men? *Pain* 153, 619-635.

Rahman, Q., Wilson, G., Abrahams, S. (2004) Sex, sexual orientation, and identification of positive and negative facial affect. *Brain Cog* 54, 179-185.

Robinson, M., Riley, J., Myers, C., Papas, R., Wise, E., Waxenberg, L., Fillingim, R. (2001). Gender role expectations of pain: Relationship to sex differences in pain. *J Pain* 2, 251-257.

Rotter, N., Rotter, G. (1988). Sex differences in the encoding and decoding of negative facial emotions. *J Nonverb Behav* 12, 139-148.

Russell, J. (1994). Is there universal recognition of emotion from facial expression - a review of the cross-cultural studies. *Psychological Bulletin* 115, 102-141.

Russell, J. (2003). Core affect and the psychological construction of emotion. *Psychol Rev* 110, 145-172.

Simon, D., Craig, K., Gosselin, F., Belin, P., Rainville, P. (2008). Recognition and discrimination of prototypical dynamic expressions of pain and emotions. *Pain* 135, 55-64.

Troje, N. (2002). Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. *J Vision*, 2, 371-87.

Vigil, J. (2009). A socio-relational framework of sex differences in the expression of emotion. *Behav Brain Sci,* 32, 375-390

Wallbott, H. (1992). Effects of distortion of spatial and temporal resolution of video stimuli on emotion attributions. *J Nonverb Behav* 16, 5-20.

Walsh, J., Eccleston, C., Keogh, E. (2014) Pain communication through body posture: The creation and validation of a stimulus set. *Pain* 155, 2282-2290.

Williams, A. (2002). Facial expression of pain: an evolutionary account. *Behav Brain Sci* 25, 439-455.

Figure captions

Figure 1: An example of a female (top) and male (bottom) stimulus, taken at the peak intensity, showing the image clarity manipulation from 100% (left), to 66% (centre), and 33% (right).

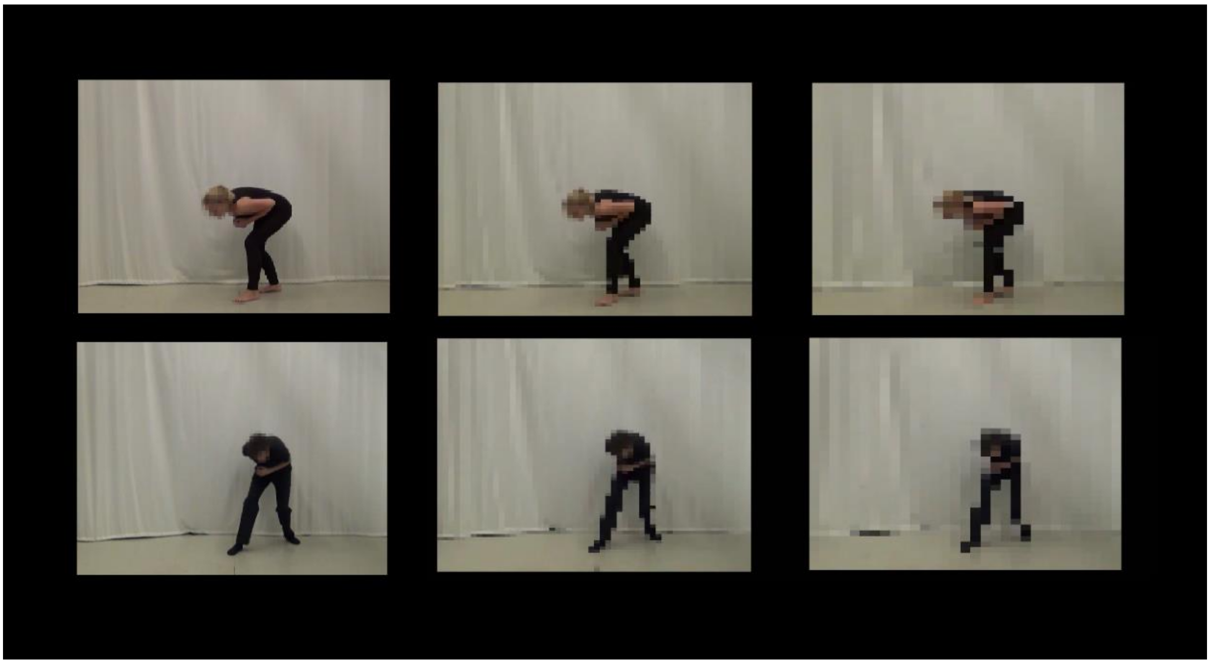


Figure 2: An illustration of the expression X image clarity interaction for intensity rating data.

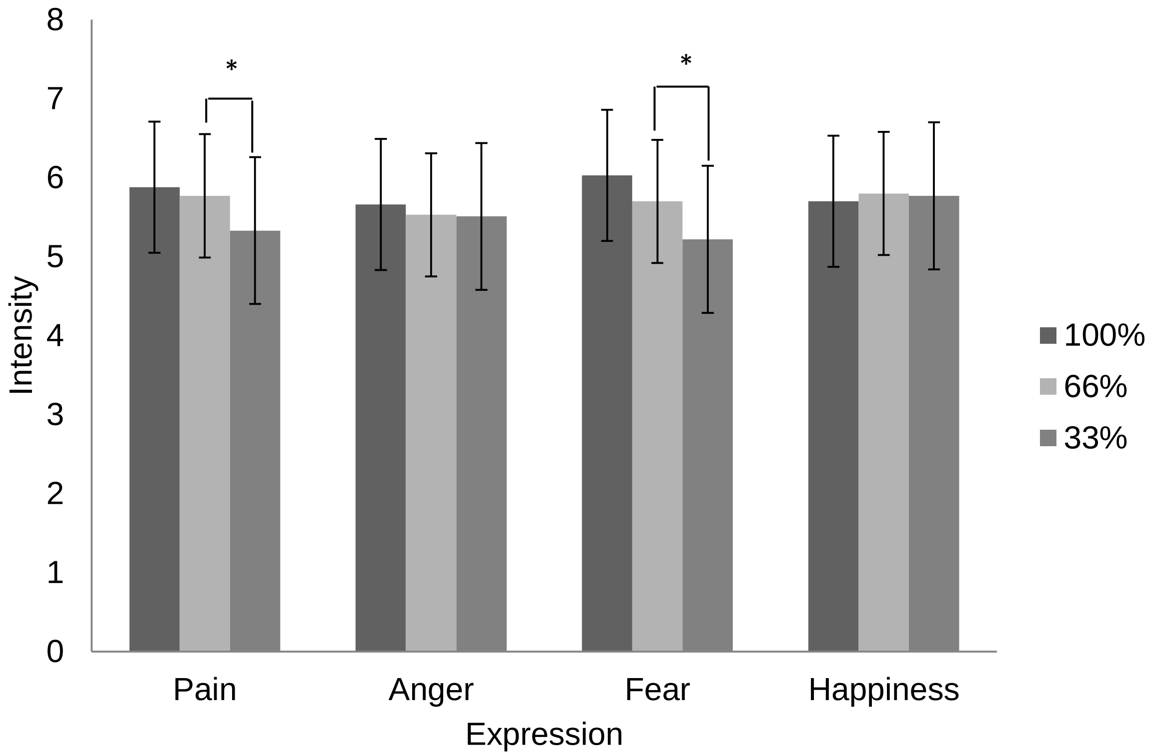


Figure 3: An illustration of the expression X actor sex interaction for intensity rating data.

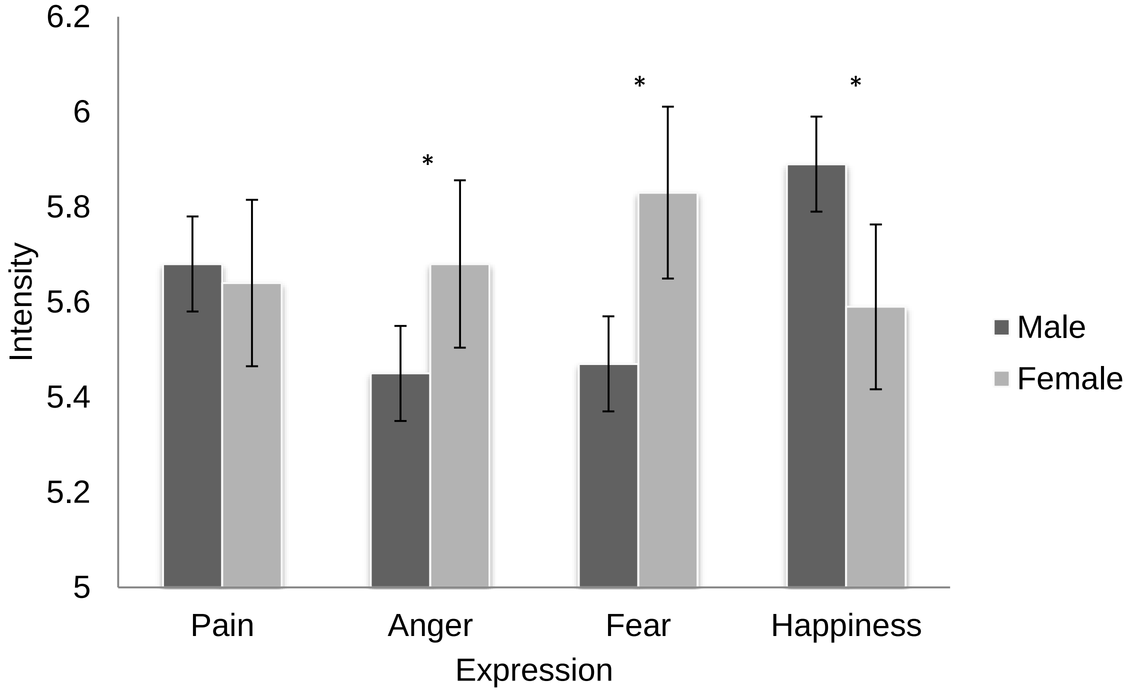


Figure 4: An illustration of the expression X image clarity interaction for hit rate recognition accuracy scores.

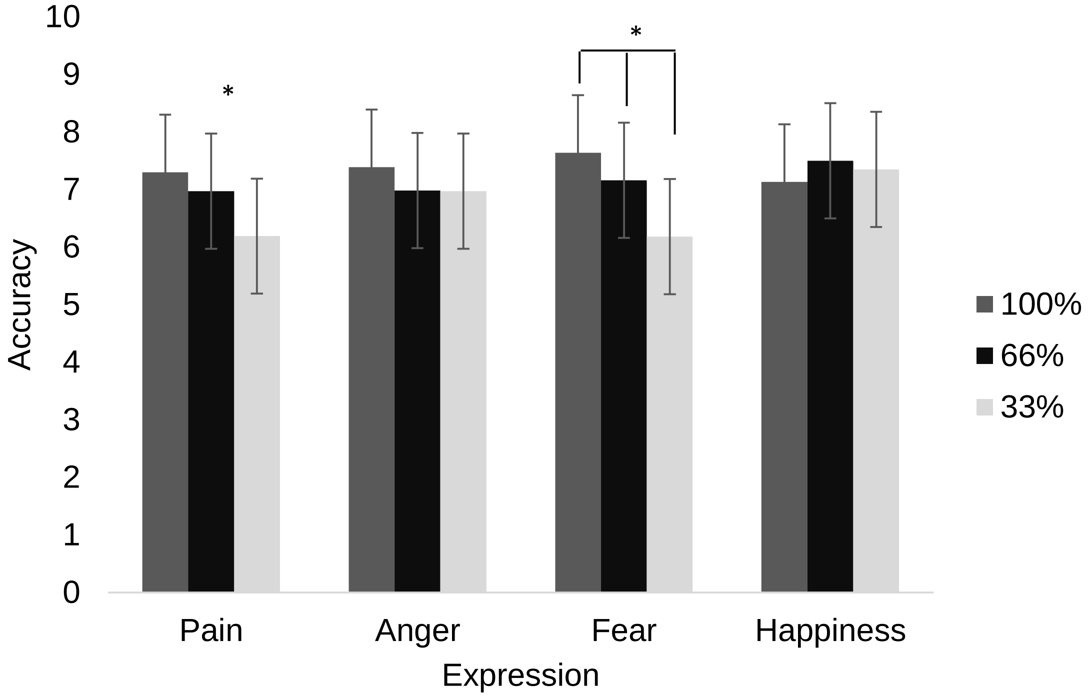


Figure 5: An illustration of the actor sex X expression interaction for recognition accuracy scores (hits).

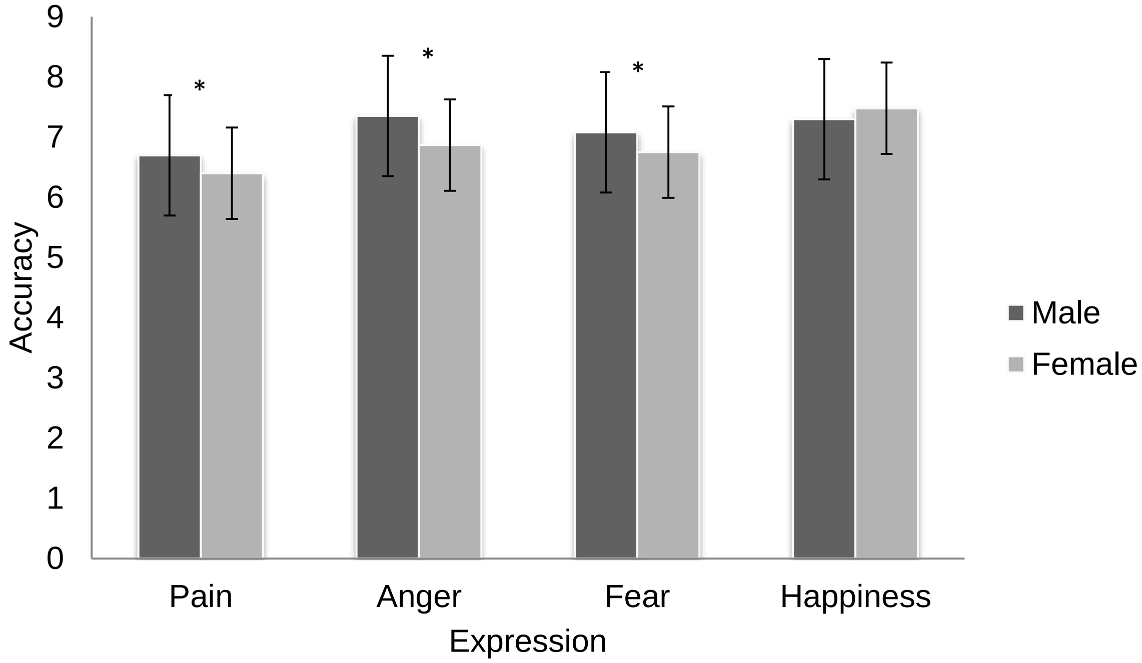
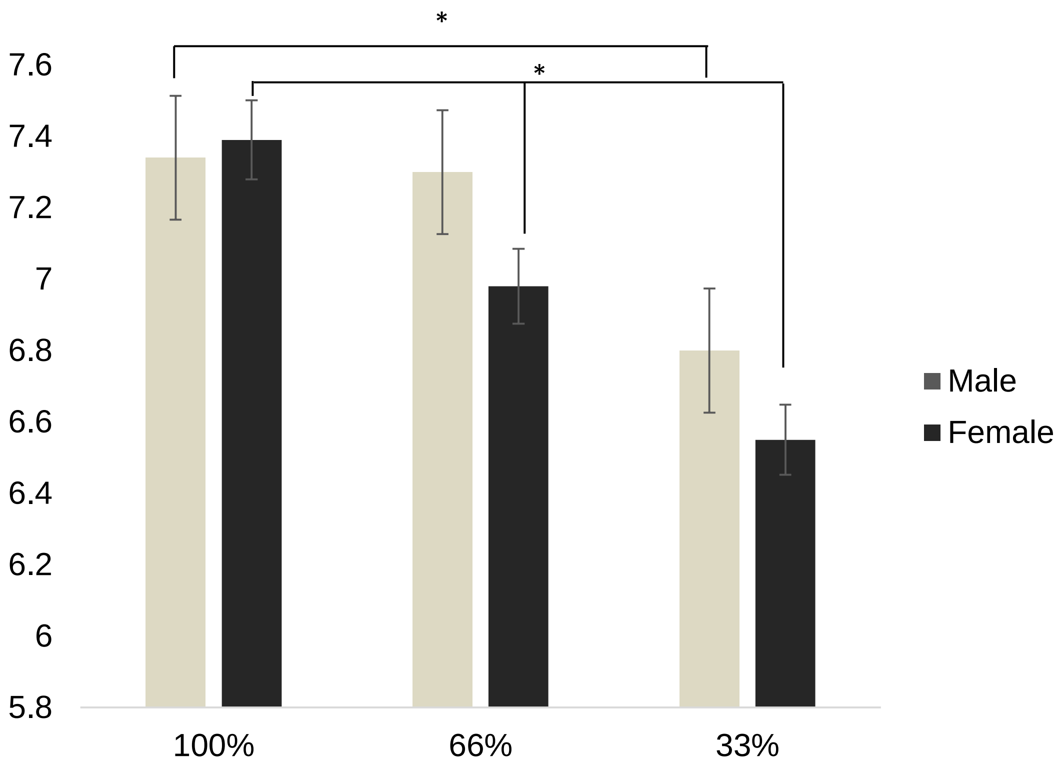


Figure 6: An illustration of the image clarity X actor sex interaction on hit rate.



Tables

Table 1: A confusion matric detailing average intensity ratings for target and nontarget expressions.

Image clarity	Participant average intensity ratings	Male actors				Female actors			
		Target expression				Target expression			
		Pain	Fear	Anger	Happiness	Pain	Fear	Anger	Happiness
100%	Pain	5.80	1.82	1.27	1.29	5.96	1.60	1.40	1.24
	Fear	1.96	5.80	1.70	1.33	2.01	5.87	1.77	1.28
	Anger	1.37	1.33	5.76	1.37	1.42	1.35	5.52	1.32
	Happiness	1.07	1.12	1.20	5.42	1.13	1.11	1.19	5.80
66%	Pain	5.70	1.98	1.38	1.22	5.71	1.73	1.42	1.25
	Fear	2.24	5.40	1.68	1.19	2.12	5.42	1.97	1.25
	Anger	1.39	1.76	5.73	1.38	1.40	1.72	5.26	1.35
	Happiness	1.11	1.20	1.22	5.51	1.10	1.15	1.15	5.84
33%	Pain	5.32	1.69	1.35	1.24	5.31	1.91	1.41	1.26
	Fear	2.50	5.92	1.73	1.23	2.39	4.93	1.82	1.23
	Anger	1.38	1.36	5.56	1.51	1.40	2.36	5.33	1.37
	Happiness	1.10	1.19	1.25	5.39	1.11	1.21	1.18	5.78

Table 2: Mean (standard deviation) values for intensity data.

Expression	Participant sex	Actor sex	Intensity		
			100% clarity (standard deviation)	66% clarity (standard deviation)	33% clarity (standard deviation)
Pain	Male	Male	5.66 (0.93)	5.90 (0.76)	5.39 (0.91)
		Female	5.88 (1.02)	5.66 (0.90)	5.27 (0.75)
	Female	Male	6.10 (0.80)	5.73 (1.04)	5.33 (0.90)
		Female	5.89 (0.70)	5.79 (0.89)	5.36 (1.41)
Anger	Male	Male	5.68 (0.84)	5.52 (1.08)	5.60 (0.83)
		Female	5.72 (0.51)	5.86 (0.93)	5.74 (0.96)
	Female	Male	5.50 (1.17)	5.13 (1.28)	5.25 (1.23)
		Female	5.73 (1.07)	5.61 (1.16)	5.44 (1.26)
Fear	Male	Male	6.12 (0.75)	5.70 (0.92)	5.39 (1.21)
		Female	6.41 (0.76)	6.09 (0.85)	5.77 (0.70)
	Female	Male	5.74 (1.07)	5.32 (1.21)	4.55 (1.38)
		Female	5.86 (0.88)	5.68 (1.19)	5.18 (1.28)
Happiness	Male	Male	5.86 (0.80)	6.08 (0.77)	6.02 (0.88)
		Female	5.76 (1.03)	5.95 (1.02)	5.82 (1.08)
	Female	Male	5.84 (0.92)	5.81 (1.09)	5.73 (1.23)
		Female	5.33 (1.21)	5.36 (1.41)	5.31 (1.27)

Table 3: Mean (standard deviation) values for intensity hit rate data.

Expression	Participant sex	Actor sex	Hit rate		
			100% clarity (standard deviation)	66% clarity (standard deviation)	33% clarity (standard deviation)
Pain	Male	Male	7.00 (1.00)	6.82 (1.02)	6.18 (1.59)
		Female	7.12 (0.70)	6.74 (1.03)	6.41 (1.18)
	Female	Male	7.13 (0.82)	6.91 (1.08)	6.17 (1.70)
		Female	7.30 (0.77)	7.30 (0.82)	6.00 (1.21)
Anger	Male	Male	7.29 (0.77)	7.41 (0.80)	7.29 (0.85)
		Female	7.35 (0.79)	6.76 (1.35)	6.76 (1.30)
	Female	Male	7.65 (0.57)	7.26 (0.92)	7.22 (1.04)
		Female	7.26 (0.75)	6.48 (1.50)	6.61 (1.16)
Fear	Male	Male	7.82 (0.39)	7.59 (0.51)	6.59 (0.80)
		Female	7.82 (0.39)	6.94 (1.14)	6.35 (1.37)
	Female	Male	7.39 (0.75)	7.48 (0.85)	6.48 (1.53)
		Female	7.48 (0.59)	6.61 (1.34)	5.30 (1.49)
Happiness	Male	Male	7.41 (0.62)	7.71 (0.69)	7.47 (1.01)
		Female	7.29 (0.85)	7.59 (0.80)	7.71 (0.47)
	Female	Male	7.04 (1.19)	7.22 (1.51)	6.96 (1.40)
		Female	7.52 (0.73)	7.48 (0.85)	7.26 (1.29)