



Facial expressions of pain in chronic pain and experimentally induced pain

Ariel Nelson

Supervised by: Katherine Finlay

November 2013

Facial expressions of pain in chronic pain and experimentally induced pain

ABSTRACT

Research has revealed the existence of genuine, exaggerated and suppressed pain facial expressions, which can be influenced by pain type, previous experience with pain, and empathy. The present study investigated how observers with and without chronic pain perceive genuine and deceptive pain expressions, in individuals experiencing chronic pain and experimental pain. The study comprised of three phases. Phase one involved collecting facial expressions of pain. Ten female participants took part (five with chronic pain and five experiencing experimental pain). Genuine, exaggerated, suppressed and neutral expressions were collected. Phase two was a pilot study of the images from Phase one. Phase three was a survey of the facial expressions. Forty three participants took part (23 with chronic pain and 20 with no pain). Participants categorised expressions and rated images' pain intensity. Findings revealed that observers struggled to distinguish between genuine and deceptive pain expressions, however experimental pain expressions were easier to read than chronic pain expressions. Similarly, observers with no pain were better at reading expressions than observers with chronic pain. Empathy had little effect on pain intensity ratings. The findings are considered with regards to previous research, and methodological limitations, implications and suggestions for future research are discussed.

| | | | | |
|------------------|-------------|---------------------|---------------------|---------------------------|
| KEY WORDS | PAIN | CHRONIC PAIN | INDUCED PAIN | FACIAL EXPRESSIONS |
|------------------|-------------|---------------------|---------------------|---------------------------|

Facial expressions of pain in chronic pain and experimentally induced pain

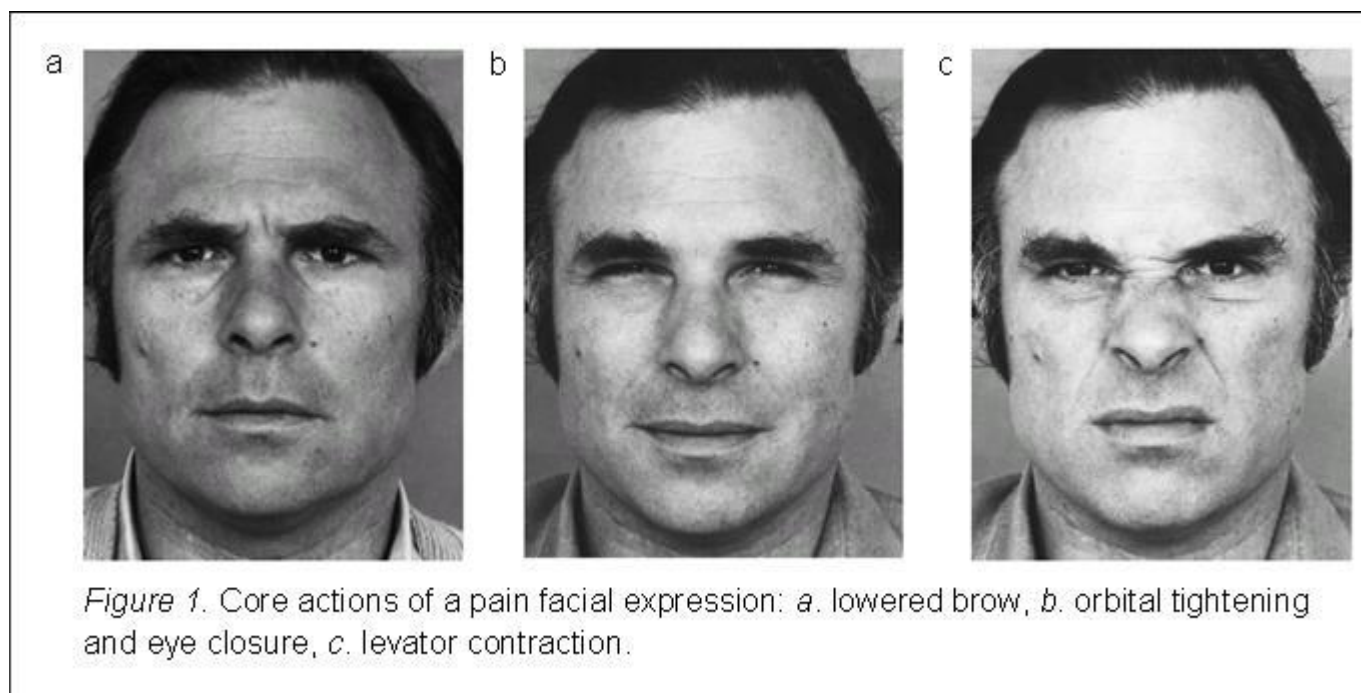
Introduction

Pain is defined as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage” (Loeser & Treede, 2008; World Health Organisation, 2012). Pain has an evolutionary adaptive function; it motivates an organism to retreat from noxious stimuli, and to avoid similar situations in the future (Hadjistavropoulos, Craig, & Fuchs-Lacelle, 2004). Pain can involve more complex functions, and in some species, such as humans, pain can function as a communicative tool (Hadjistavropoulos et al., 2004). Pain communication involves exhibiting verbal and non-verbal expressions of pain, such as groaning, crying and grimacing expressions (Keefe, Williams, & Smith, 2001). Non-verbal communications of pain, such as facial expressions, contribute a major proportion of information conveyed in social interactions, with as much as two-thirds of information coming from non-verbal actions (Mehrabian, 1968). Judgments about an individual's experience of pain tend to be biased towards non-verbal expressions, particularly facial expressions, as they are viewed as being beyond voluntary control (Craig, Prkachin, & Grunau, 2011).

Darwin (1875/1998) was one of the first to study the nature of pain facial expressions, and in the last century, a vast amount of research has been undertaken to investigate facial expressions of other emotions, such as joy, sadness and fear. Ekman et al. provide evidence suggesting that there are unique and identifiable facial expressions for specific emotions (Ekman, Sorenson, & Friesen, 1969; Ekman, 1999). Similar facial expressions of distinct emotions are found cross-culturally, indicating that these distinct expressions may be elicited by particular inner experiences (Ekman et al., 1969). For instance, physiological arousal associated with a fearful situation gives rise to particular movements of specific facial muscles, resulting in a prototypical fear expression (Hager & Ekman, 1983). Ekman (1999) describes how basic emotions, such as anger, fear and disgust, involve unique physiological reactions, cognitive appraisals and resulting patterns of behaviour, such as facial expressions. Similarly, pain is viewed as a distinct physical sensation and psychological experience (Craig, 2003; Sengupta & Kumar, 2005). With this in mind, facial expressions of pain, as comparable to emotional facial expressions, should show similar characteristics, being unique and identifiable. Schiavenato et al. (2008) looked at pain facial expressions of neonates, and found evidence for a common facial expression of pain. The pain facial expression of new-borns was found to be structurally similar to that of adults (Schiavenato et al., 2008). Likewise, Prkachin (1992) showed that pain expressions in adults are similar over the lifespan. This suggests that pain facial expressions are unique and universal, as they are apparent from birth and continue unchanged throughout adult life (Williams, 2002). Thus, facial expressions of pain should be broadly constant across individuals, regardless of culture or age.

The Facial Action Coding System (FACS) is a system used to code facial actions during expression of emotions (Ekman, Friesen, & Hager, 2002). FACS has been used to identify specific facial muscles which move in reaction to distinct emotions (Ekman & Friesen, 2003), and to pain (Prkachin, 2009). Prkachin (1992) identifies pain facial expressions by four core actions; eye closure, orbital tightening, brow lowering and levator contraction (contraction of the muscles surrounding the nose and possible upper lip raising; see *Fig. 1*). These four components have been found to be apparent during pain experiences across all ages, from neonates to the elderly (Larochette, Chambers, & Craig, 2006; Prkachin & Solomon, 2008; Schiavenato et al., 2008), and across different pain modalities, from chronic to experimental pain (Craig, Hyde, & Patrick, 1991; Littlewort, Bartlett, & Lee, 2007; Prkachin, 1992). This is evidence to support the notion of a universal 'pain face', which is recognisable on the basis of several core facial muscle movements. Thus, to be characterised as representing pain, a facial expression should exhibit these four core movements.

Nonetheless, there is evidence of subtle differences in pain expressions. For instance, Hill and Craig (2002) used FACS to demonstrate discernible differences between different types of pain expressions. Genuine and deceptive facial expressions were investigated, where genuine expressions were pure reactions to pain, and deceptive expressions were faked and masked expressions of pain. Genuine expressions were characteristic of the pain face (eye closure, orbital tightening, brow lowering and levator contraction), while faked pain expressions were exaggerations of these characteristics. Masked expressions tended to be similar to neutral expressions, but showed evidence of leakage of the pain face characteristics (Hill & Craig, 2002). This is evidence that FACS can be used to distinguish different facial expressions of pain. However, it is important to note that FACS has been criticised for its lack of ecological validity (Russell, 1994), thus it is important to consider how untrained observers judge pain expressions.



Prkachin, Berzins and Mercer (1994) showed that observers are less reliable than FACS coding when discriminating between pain facial expressions. Even so, observers were able to discriminate between minor and major pain experiences (Prkachin et al., 1994). Similarly, Hadjistavropoulos, Craig, Hadjistavropoulos and Poole (1996) showed that untrained observers can distinguish between genuine and deceptive pain expressions. Where neutral and exaggerated pain expressions, which represent extremes of the pain face, were more accurately identified than genuine and suppressed pain expressions. This suggests that different facial expressions are recognisable in a more realistic context, where observers can recognise different portrayals of pain expressions.

Empathy and pain

Facial expressions do not occur in isolation; in order for an observer to understand an expression, there should be some purpose behind the communication. Darwin (1875/1998) proposed that non-verbal expressions, particularly facial expressions, evolved primarily as a communicative tool for social interactions. Indeed, research has suggested that the presence of others in a social situation tends to increase facial expressiveness, relative to expressiveness in isolation (Wagner & Lee, 1999). Thus, it is necessary to consider the social function of non-verbal pain communication, as this can influence the expression, and judgement of a pain experience. Hadjistavropoulos et al. (2004) discussed the functions of pain communication, and suggest that pain in others may be an indication of danger to the self, where seeing someone else in pain has an adaptive advantage, as it allows the viewer to infer a possible threat to the self, and act accordingly.

Conversely a subjective experience of pain can generate helping behaviours from others. This is an adaptive response, where expressing pain, and having others recognise it, can result in altruistic and potentially protective behaviour (Hadjistavropoulos et al., 2004). This requires the ability to recognise pain expressions, and in order for a reaction to one's pain, it is necessary that individuals have a notion of what the other is feeling, and the implications of this experience for all involved (van Hooft, 2003). As van Hooft (2003) argues, communicating one's pain can act as a plea for help, appealing to the empathy of others.

Empathy is the ability to perceive and understand how others are feeling (Kalisch, 1973), and is thought to be a crucial component in the process of identifying pain to induce altruistic behaviours (Goubert et al., 2005; van Hooft, 2003). Without empathy it would be difficult for others to recognise and help an individual in pain (Goubert et al., 2005). However, the elicitation of helping behaviours and empathy may be moderated by several factors (Goubert et al., 2005). For instance, helping behaviour and empathy can be influenced by prior experience with pain. Jackson, Meltzoff and Decety (2005) showed that viewing someone in pain was more likely to elicit empathy if the observer had had a similar pain experience. This suggests that top-down, cognitive processes play a role in empathy and helping behaviours, as having a similar pain experience can influence an observer's empathy, and how they react to someone in pain. Thus, it is important to establish how observers with and without previous experience of pain react to facial expressions of pain, and whether their empathy levels affect how they perceive pain on others.

Different levels of empathy may be implicated in how individuals view pain expressions. For instance, Green, Tripp, Sullivan and Davidson (2009) suggest that higher levels of empathy are linked to the ability to internalise others' experiences, and an increased understanding of others' pain. This suggests that individual differences in empathy could affect how people view and respond to pain expressions. Green et al. (2009) investigated the link between empathy and observers' estimates of pain in senders' facial expressions. Results showed that observers with high levels of empathy tended to estimate a higher pain experience on behalf of the sender (Green et al., 2009). This suggests that different levels of empathy may influence how observers view the intensity of pain experienced by others, where higher levels of empathy leads to higher estimates of pain experiences. It is therefore important to consider how empathy levels influence observers' views of pain facial expressions, and how this affects their perception of pain experience.

It is important, however, to distinguish between the effect empathy has on ratings of pain intensity pain experienced by an individual, and accuracy in detecting genuine and deceptive facial expressions of pain. Hill and Craig (2004) investigated observers' accuracy in distinguishing between different pain facial expressions (genuine, faked and masked). Results indicated that empathy and accuracy were unrelated; levels of empathy had little impact on observers' accuracy in categorising different facial expressions (Hill & Craig, 2004). This suggests that empathy is unrelated to accuracy in detecting deception in pain expressions. Taken together, this shows that empathy plays a role in how observers view pain experiences. Where empathy levels affect how observers rate the pain intensity of others' experiences, but have no impact on the ability to accurately identify genuine and deceptive expressions. Thus it is necessary to consider empathy in the investigation of how observers view different facial expressions of pain.

Chronic pain and pain expressions

Chronic pain is pain which is experienced for longer than three months, or which continues past the expected time of healing (Merskey & Bogduk, 1994). It can be compared to acute pain, which is characterised by sudden onset as a result of an underlying cause, which when healed leads to a resolution of pain (Shiel & Stoppler, 2012). Chronic pain can have severe consequences on sufferers' everyday lives; affecting their physical abilities (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006), their emotional states (Gamsa, 1990), and their cognitive processing (Pincus & Morley, 2001). Chronic pain sufferers experience biases in their cognitive processing, where their attention and processing is biased towards pain-related stimuli (Pincus & Morley, 2001). Hence, chronic pain sufferers may struggle to disengage their attention away from pain-related stimuli. In support of this notion, Pearce and Morley (1989) demonstrated that chronic pain patients' performance on a Stroop task (naming the colour of a word instead of naming the word itself) decreased when they were presented with pain-related words. Chronic pain patients struggled to disengage their attention from pain-related words, suggesting at interferences in the processing of additional information when viewing pain-related stimuli. This demonstrates that previous experience with pain can affect how

individuals process pain-related information, and may impact how they see facial expressions of pain.

Similarly, displays of pain facial expressions may be influenced by prior experience with pain. Saarela et al. (2007) suggest that chronic pain sufferers' facial expressions are more 'real' than those of volunteers undergoing experimental pain. This may be due to the meaning of pain for chronic pain sufferers, which cannot be understood by healthy individuals, where there are differences between pain expressions of chronic pain sufferers, and healthy individuals with no previous pain experience. Thus it is important to establish whether there are differences between the facial expressions of individuals with and without chronic pain. Nonetheless Craig et al. (1991) propose that there are considerable individual differences within pain expressions, as compared to differences between different types of pain expressions. Thus, it may be that chronic pain sufferers and healthy volunteers experiencing acute pain demonstrate more individual differences than differences between groups. As Craig et al. (1991) point out, there is little research examining the differences between participants with prolonged experiences of pain (chronic pain), and participants who have limited experience of pain. Thus, there is a clear need to explicitly examine differences in facial expressions of pain, from individuals experiencing chronic pain and experimental pain.

Research has demonstrated that different types of pain expressions can be differentiated by untrained observers (Hadjistavropoulos et al., 1996). The present study aims to further investigate observer judgements, as naturalistic observations of pain do not rely on time consuming coded information, but rather rely on an observer's prior experience, contextual cues and quick judgements (Pantic & Rothkrantz, 2000). The aim of this study is to investigate naïve observers' judgements of pain facial expressions, and to establish whether there are recognisable differences between chronic pain sufferers and healthy volunteers' expressions of genuine, exaggerated and suppressed pain. Similarly, as Craig et al. (1991) and Williams (2002) point out, there is little research looking explicitly at the differences in facial expressions of chronic pain sufferers versus healthy volunteers. Therefore, a second aim is to establish whether differences exist between chronic and experimental pain facial expressions.

A related aim is to establish whether judgements of genuine and deceptive pain expressions are affected by prior experience with pain. Prior research has shown that chronic pain sufferers' cognitive processing of pain related stimuli, and pain facial expressions are affected by their prolonged experience with pain (Pearce & Morley, 1989; Prkachin et al., 2004; Vervoort et al., 2013) Thus, with chronic pain sufferers and healthy volunteers as observers, the difference between the groups' accuracy in recognising deceptive and genuine pain expressions, and pain intensity ratings, will be investigated. Lastly, it has been shown that empathy affects ratings of pain intensity (Green et al., 2009; Ruben & Hall, 2013), yet empathy has been shown to have little effect on accuracy in distinguishing different types of pain facial expressions (Hill & Craig, 2004). Thus, a final aim is to investigate the link between empathy and recognition and ratings of pain facial expressions.

Hypotheses

- Observers will be able to distinguish between genuine, exaggerated and suppressed pain expressions.
- There will be a difference between observers' accuracy in categorising images of chronic pain versus experimental pain faces.
- There will be a difference between chronic pain and 'no pain' observers' accuracy in identifying genuine and deceptive pain facial expressions.
- Observers with high levels of empathy will rate the pain intensity of facial expressions higher than observers with low levels of empathy.

Method

The study took place in three phases: (1) pain stimulation and facial expression data collection, (2) data preparation and pilot study, and (3) observer judgements.

Phase 1

Participants

Facial expression data was collected for 16 participants (male: $n = 6$). Male participants were excluded, as an insufficient number of men with chronic pain were recruited ($n = 1$). This reflects the general pain population, where chronic pain is more prevalent in females than males (Johannes, Le, Zhou, Johnston, & Dworkin, 2010). The final sample of female participants ($n = 10$) were divided into chronic pain sufferers and healthy volunteers.

Chronic pain sufferers were five female volunteers. Participant age ranged from 48 to 69 years ($M = 55.80$; $SD = 8.23$). Participants had been experiencing pain for between 7 to 28 years ($M = 13.20$; $SD = 8.90$). Participants were recruited from a local chronic pain support group (Aylesbury Vale Fibromyalgia Group).

Healthy volunteers were five females. Participant age ranged from 19 to 25 years ($M = 21.60$; $SD = 2.30$). Participants had no previous experience with chronic pain. Participants were recruited by convenience sampling from the University of Buckingham.

Design

The dependent variable (DV) was pain intensity after each activity, measured on a numerical rating scale. The independent variables (IVs) were group membership (2 levels: chronic pain sufferers and health volunteers) and facial expressions (4 levels: genuine, exaggerated and suppressed pain, and neutral). A within-participants design was employed, in that each participant took part in all conditions. The four conditions included a neutral (baseline) facial expression, a genuine facial reaction to pain, an exaggerated pain facial expression and a suppressed pain facial expression.

Apparatus

Filming equipment: A video recorder and tripod from the University of Buckingham's Psychology lab were used to film participants' facial expressions.

Cold pressor test equipment: A Cold Pressor Test (CPT) machine was used, with the water at a constant temperature of 0°C. Hot water bottles and towels were used to warm participants' hands. A thermometer was used to monitor participants' hand temperatures.

Pain induction stimuli: Chronic pain participants chose a normal daily activity which temporarily exacerbated their current pain. Healthy volunteers immersed their hands in 0°C water during the cold pressor test.

Materials

Pain history questionnaire: An 11-item pain history questionnaire was used to investigate participants' previous experience with pain.

Brief Pain Inventory (BPI): The BPI is a 9-item pain inventory used to measure pain experience (Cleeland & Ryan, 1994). The BPI has been shown to be a reliable and valid measure of pain experience (Tan, Jensen, Thornby, & Shanti, 2004).

Numerical rating scales (NRSs): NRSs are 11-point scales ranging from 0 = 'no pain' to 10 = 'worst possible pain'. NRSs were used to measure participants' experience of pain intensity and pain distress. NRSs have been shown to be reliable, valid and sensitive measures of pain experience (Williamson & Hoggart, 2005).

Short Form McGill Pain Questionnaire-2 (SF-MPQ-2): The SF-MPQ-2 is a 15-item questionnaire measuring sensory and affective aspects of pain experience (Dworkin et al., 2009). Pain descriptor items are rated for intensity on a scale from 0 = 'none' to 10 = 'worst possible'. The SF-MPQ-2 has been shown to be a reliable and valid measure of pain experience (Dworkin et al., 2009).

Procedure

Participants were given a brief to read over, and were required to give signed consent for their participation and for the later use of their films. Chronic pain participants discussed their pain experience with the researcher beforehand, and decided on an appropriate pain-inducing activity to perform for the purposes of the study. They were urged to perform a usual activity from their daily lives which caused them temporary pain (*e.g. putting on shoes*).

Prior to filming, all participants completed the PHQ and BPI. A neutral (baseline) facial expression was filmed before the pain inducing activities. Participants performed the pain-inducing activity (self-directed activity or CPT) three times, one each for a genuine, exaggerated and suppressed reaction to pain. The order of the three pain facial expressions was counterbalanced across participants. Participants were advised to have a rest and recovery phase between each activity. During each rest session, participants completed NRSs (for pain intensity and distress) and the SF-MPQ-2. CPT participants were given hot water bottles to warm up their hands. Their hand temperatures were measured to ensure their temperature returned to

baseline before the next activity. All participants were advised to begin the next activity only when they had fully recovered. At the end of the session, participants were debriefed, encouraged to ask any questions, and thanked for their participation. Participants were advised throughout the session to cease performing any activities when desired. Participants were also advised to contact their GP should they experience any adverse effects from the study. Participants were informed that they could request a copy of the final written report, if they so wished.

Statistics and analysis

The data were analysed by *t*-tests (paired-samples and independent-samples) and within-subjects ANOVAs. The dependent variable under investigation was pain intensity ratings. The independent variables under investigation were experimental intervention (2 levels: pre- and post-pain), facial expression type (4 levels: genuine, exaggerated, suppressed and neutral) and pain type (2 levels: chronic pain and experimentally induced pain).

Phase 2

Participants

Participants were 3 female and 2 male volunteers ($n = 5$). Participant age ranged from 23 to 58 years ($M = 36.40$; $SD = 16.79$). Participants were recruited from the local community.

Materials

Category choice: A four-choice categorisation was used to measure participants' accuracy in identifying the different pain expressions (genuine, exaggerated, suppressed and neutral).

Numerical rating scales (NRSs): 11-point NRSs were used to measure clarity of pain expressions (0 = 'extremely unclear' to 10 = 'extremely clear') and confidence in answers (0 = 'extremely unconfident' to 10 = 'extremely confident').

Procedure

The data were prepared by the researcher. Raw film footage was converted into still images, which were analysed so that images of the different pain expressions were identified (genuine, exaggerated, suppressed and neutral expressions). Analysis of the facial expression data was influenced by the FACS coding system, so that a valid pain expressions stimulus set was developed. For facial expressions to be classified as representing pain, the presence of four core pain facial movements (eye closure, orbital tightening, brow lowering and levator contraction) had to be apparent (Prkachin, 1992). This resulted in a sample of 80 images, with 20 images of each of the genuine, exaggerated, suppressed and neutral expressions. Participants viewed each image, and categorised the image as representing a genuine, exaggerated, suppressed or neutral expression. Participants then rated each image in terms of the clarity of the facial expression, and their confidence in their answers.

Statistics and Analysis

Accuracy scores were derived from the total number of correct categorisations compared to the highest possible number of correct categorisations. Final images used in phase 3 of the study were chosen on the basis of a minimum accuracy score of 60% (following Littlewort et al., 2007). Where two images had the same accuracy score, a final image was chosen with reference to the higher clarity and confidence levels. A total of 40 images were chosen for phase 3 of the study. Images were comprised of four images of each participant, with five participants experiencing chronic pain, and five participants experiencing experimentally induced pain. Images were divided into 10 of each facial expression type; genuine, exaggerated, suppressed and neutral facial expressions (see *Appendix A*).

Phase 3

Participants

Participants were divided into chronic pain sufferers and healthy volunteers. Chronic pain sufferers were 18 female and 5 male volunteers ($n = 23$). Participant age ranged from 20 to 64 years ($M = 43.52$; $SD = 14.09$). Participants had been experiencing pain for between 1 to 30 years. Participants were recruited online via chronic pain forums. Healthy volunteers were 11 female and 9 male ($n = 20$). Participant age ranged from 19 to 77 years ($M = 33.30$; $SD = 16.30$). Participants had little or no previous experience with chronic pain (years experiencing chronic pain $M = 1.55$; $SD = .51$). Participants were recruited by convenience sampling from the local community, University of Buckingham and online via psychology forums.

Design

A mixed design was used. The between-subjects variable was group (2 levels: chronic pain sufferers and health volunteers). The within-subjects variables were pain intensity ratings and accuracy.

The order of images was randomised for each participant. The dependent variables (DVs) were accuracy in categorising facial expressions into one of four categories (genuine, exaggerated, suppressed and neutral) and pain intensity ratings. The independent variables (IVs) were group membership (2 levels: chronic pain sufferers and health volunteers), and the empathy levels of each participant.

Materials

Pain history questionnaire: An 11-item pain history questionnaire was used to establish participants' previous experiences with pain.

Toronto Empathy Questionnaire (TEQ): The TEQ is a 16-item questionnaire measuring levels of empathy (Spreng, McKinnon, Mar & Levine, 2009). The TEQ has been shown to be a reliable and valid measure of empathy levels (Celik, Saritas, & Catalbas, 2013).

Category choice: A four-choice categorisation was used to measure participants' accuracy in detecting the different pain expressions (genuine, exaggerated, suppressed and neutral). A three-choice categorisation was used to measure participants' accuracy in distinguishing between the different types of pain (chronic pain, experimental pain and no pain/neutral).

Numerical rating scales (NRSs): 11-point NRSs were used to measure image pain intensity (0 = 'no pain' to 10 = 'worst possible pain'), and confidence in ratings and categorisation (0 = 'extremely unconfident' to 10 = 'extremely confident').

Procedure

Participants were given a brief outline of the study and gave informed consent before taking part. Participants completed the PHQ and TEQ prior to the observation and judgement tasks. Participants viewed each image and were requested to categorise the image's expression type and pain type. Following this, participants used NRSs to rate the pain intensity of each expression, as well as their confidence in their answers. Once participants had completed their observations and judgements, they were debriefed and thanked for their participation. Participants were informed that they could request a copy of the final written report, if they so wished.

Statistics and analysis

Accuracy: Accuracy scores were obtained where observers correctly categorised images of the four facial expressions (genuine, exaggerated, suppressed and neutral). The data were analysed by *t*-tests (paired-samples and independent-samples), within-subjects ANOVAs and Bonferonni post hoc comparisons. The dependent variable under investigation was accuracy score. The independent variables under investigation were facial expression type (4 levels: genuine, exaggerated, suppressed and neutral expressions), gender (2 levels: male and female), volunteer pain type (2 levels: chronic pain and experimentally induced pain) and observer pain condition (2 levels: chronic pain and no pain).

Empathy: Individual empathy raw scores were compared to the median empathy score (as in Spreng et al., 2009), and observers were categorised as having high or low levels of empathy, dependant on whether they were above or below the median, respectively. The data were analysed by a Pearson's correlation and independent-samples *t*-test. The dependent variable was pain intensity. The independent variables were empathy raw score and empathy level (2 levels: high and low).

Pain intensity: The data were analysed by a paired-samples *t*-test and a MANOVA. The dependent variable was pain intensity rating (4 levels: genuine, exaggerated, suppressed and neutral expressions). The independent variables were volunteer pain type (2 levels: chronic pain and experimentally induced pain), and observer pain condition (2 levels: chronic pain and no pain).

Ethics

The study was approved by the University of Buckingham's School of Science and Medicine Ethics Committee, and meets current ethical standards and requirements. For phase 1 of the study, chronic pain sufferers engaged in an activity which did not

exceed any physical distress which they experience in normal daily life. This resulted in a pain experience which was temporary and had no lasting effects. Participants' activities were self-directed, and they could cease the activity whenever they felt appropriate. The experimental pain activity made use of the Cold Pressor Test, which induced temporary pain in the healthy volunteers. The pain caused no damage, and had no lasting effects. Participants could remove their hand from the cold pressor machine when they felt appropriate, with a maximum submersion time of four minutes.

Throughout the study all participants were required to give informed consent prior to taking part. They were informed that they could withdraw their participation at any point in the study, and that any data collected up to that point would be removed. Participants' personal details remained anonymous.

Results

Phase 1

The data were analysed to establish if participants were experiencing pain at the time of filming (manipulation check), and to compare pain intensity ratings across different facial expressions and types of pain.

Table 1

Means and standard deviations of pain ratings for chronic pain and experimentally induced pain

| | Chronic pain | | Experimentally induced pain | |
|-------------------------------|--------------|-----------|-----------------------------|-----------|
| | <i>M</i> | <i>SD</i> | <i>M</i> | <i>SD</i> |
| Chronic pain severity | 5.60 | 1.90 | - | - |
| Chronic pain interference | 6.03 | 2.79 | - | - |
| Pre-pain intensity rating | 6.00 | 2.79 | 0.80 | 0.30 |
| Genuine pain intensity | 7.20 | 2.28 | 6.60 | 2.30 |
| Exaggerated pain intensity | 7.40 | 1.14 | 6.00 | 2.24 |
| Suppressed pain intensity | 7.80 | 1.30 | 5.40 | 2.07 |
| Overall (post) pain intensity | 7.44 | 1.28 | 4.93 | 2.28 |

A paired samples *t*-test revealed a significant difference between pre-pain intensity and post-pain intensity ratings, $t(9) = 4.29$; $p < .005$. Post-pain intensity ratings were higher than pre-pain intensity ratings (see *Table 1*).

A within-subjects ANOVA revealed no significant differences for pain intensity across all tests. There were no significant differences in pain intensity between facial expressions of chronic pain participants, $F(2, 8) = .44$; $p > .05$, and experimental pain participants $F(2, 8) = 1.71$; $p > .05$.

An independent-samples *t*-test revealed a significant difference between pain intensity ratings for chronic pain and experimentally induced pain, $t(14) = 2.45$; $p < .05$. Chronic pain participants rated their pain as more intense than experimental pain participants (see *Table 1*).

Phase 3

The data were analysed in accordance with each hypothesis.

Overall accuracy: Accuracy scores for each of the four facial expressions (genuine, exaggerated, suppressed and neutral) were compared. A within-subjects ANOVA indicated a significant difference in the mean accuracy scores across the four facial expressions, $F_{3, 126} = 13.20$; $p < .0001$. Bonferroni corrected post hoc comparisons showed significant differences between genuine and neutral facial expressions ($p < .0001$), exaggerated and neutral facial expressions ($p < .001$) and suppressed and neutral facial expressions ($p < .0001$). No other comparisons were significant. Neutral facial expressions were categorised correctly more often than genuine, exaggerated and suppressed facial expressions, as demonstrated by a higher mean accuracy score (see *Table 2*). Accuracy scores for genuine, exaggerated and suppressed facial expressions were not significantly different from one another. An independent-samples *t*-test revealed no significant difference between male and female observers' accuracy scores, $t(41) = .40$; $p > .05$.

Table 2

| Facial expressions mean percentage accuracy scores | Accuracy scores (%) | |
|--|---------------------|-----------|
| | <i>M</i> | <i>SD</i> |
| Genuine facial expression | 40.93 | 18.49 |
| Exaggerated facial expression | 50.70 | 18.05 |
| Suppressed facial expression | 48.60 | 24.84 |
| Neutral facial expression | 67.91 | 22.31 |
| Total accuracy | 52.03 | 11.36 |

Pain type accuracy: Accuracy scores for images of volunteers experiencing chronic pain, and healthy volunteers undergoing experimental pain were compared. A paired-samples *t*-test revealed a significant difference between mean accuracy

scores for images of chronic pain volunteers versus experimental pain volunteers, $t(42) = 5.23$; $p < .0001$. Images of healthy volunteers undergoing experimental pain ($M = 56.74$; $SD = 12.36$) were categorised correctly more often than images of volunteers experiencing chronic pain ($M = 47.33$; $SD = 12.97$; see Fig. 2).

Observer accuracy: Accuracy scores of observers with chronic pain and observers with no pain were compared. An independent samples t -test revealed a significant difference between chronic pain and 'no pain' observers' mean accuracy score, $t(41) = -2.16$; $p < .05$. Observers with no pain had a higher mean total accuracy score ($M = 55.88$; $SD = 10.68$) than chronic pain observers ($M = 48.70$; $SD = 11.08$; see Fig. 3).

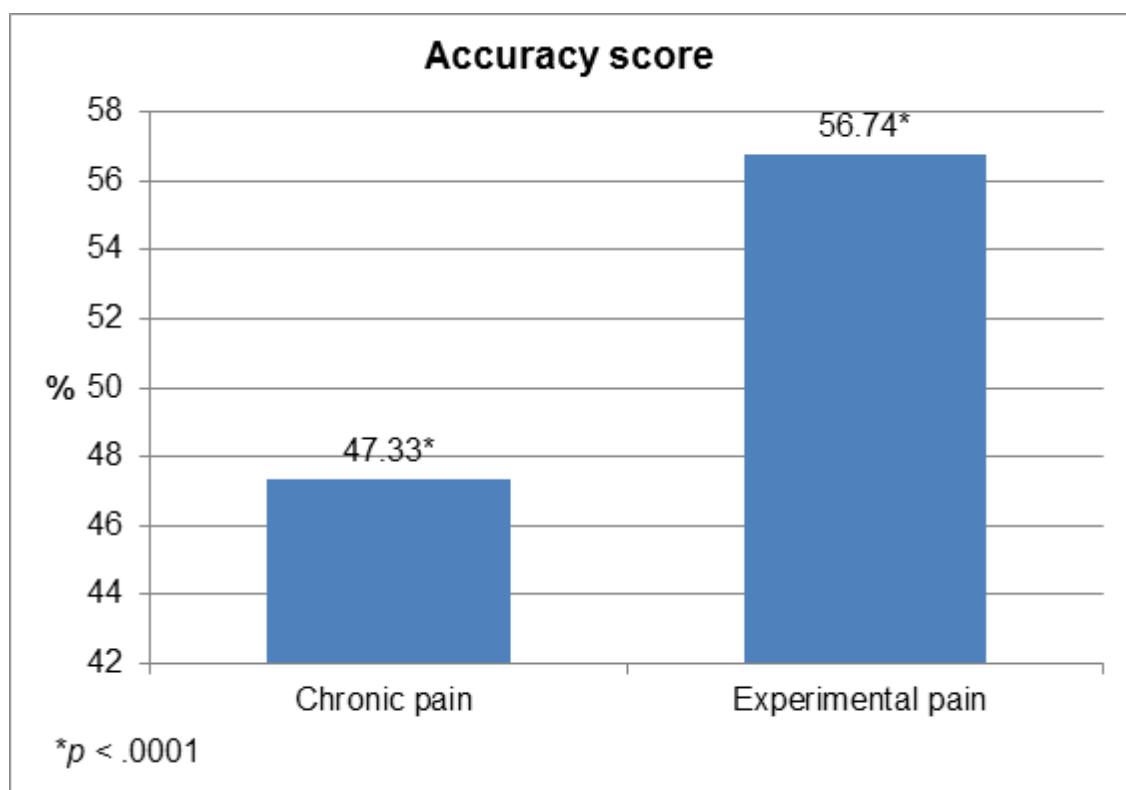


Figure 2: accuracy scores for images of chronic pain and experimentally induced pain.

Empathy and pain intensity: Observer empathy was compared to ratings of pain intensity. A Pearson's correlation revealed no significant correlation between empathy scores and pain intensity ratings, $r = .079$; $p > .05$. An independent samples t -test revealed no significant difference between pain intensity ratings of observers with high versus low levels of empathy, $t(41) = -.903$; $p > .05$ (see Table 3).

Pain intensity ratings: Observer pain intensity ratings were compared across image pain type and facial expression type. A paired samples t -test revealed a significant difference between pain intensity ratings of individuals experiencing chronic pain and experimentally induced pain, $t(42) = 4.59$; $p < .0001$. Individuals experiencing

chronic pain received higher pain intensity ratings than individuals experiencing experimentally induced pain (see Table 3).

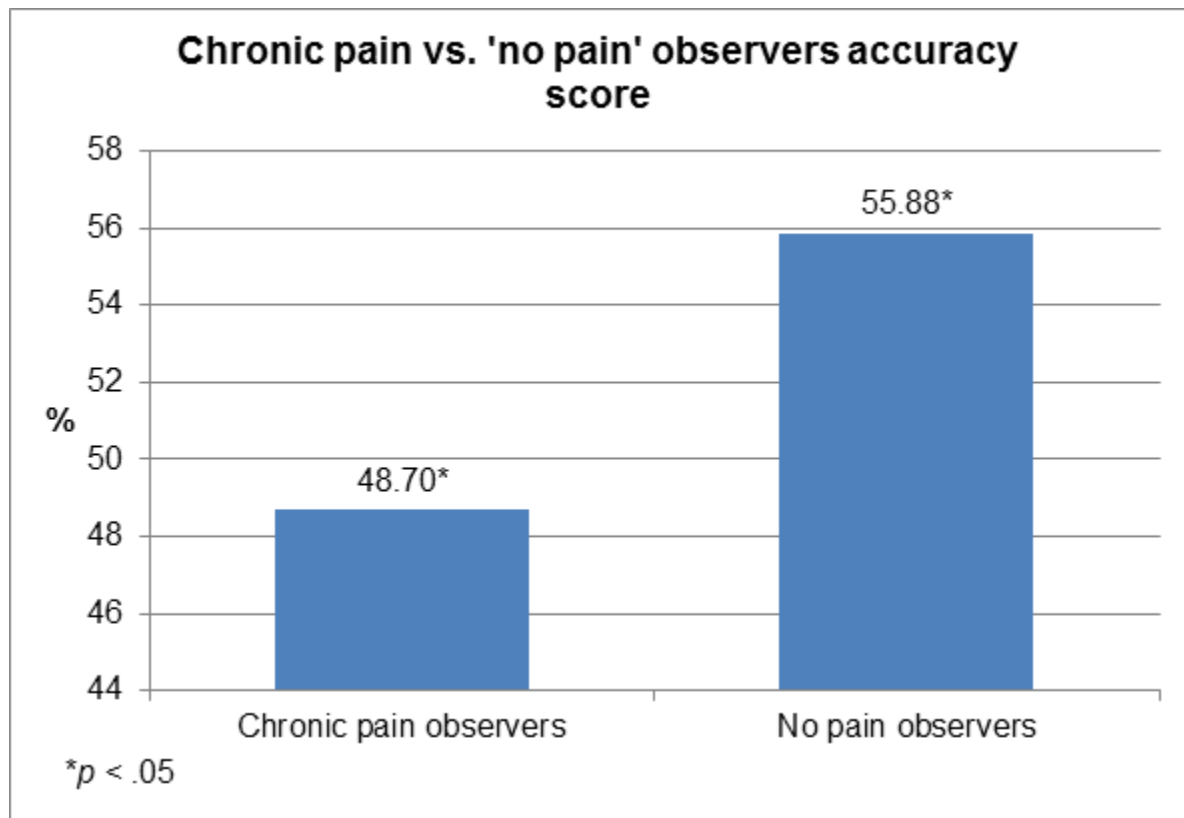


Figure 3: accuracy scores of observers with chronic pain and observers with no pain

Table 3

Means and standard deviations of empathy scores and pain intensity ratings

| | <i>M</i> | <i>SD</i> |
|--|----------|-----------|
| Empathy score | 33.30 | 4.55 |
| High levels of empathy pain intensity | 3.63 | 1.33 |
| Low levels of empathy pain intensity | 3.29 | 1.17 |
| Chronic pain faces pain intensity | 4.46 | 1.51 |
| Experimental pain faces pain intensity | 3.71 | 1.75 |
| Total pain intensity rating | 3.45 | 1.24 |

A MANOVA indicated a significant effect of pain group on neutral expression pain intensity rating, $F(1, 41) = 8.77$; $p < .001$. No other effects were significant. Chronic pain observers rated neutral expressions as having higher pain intensity than 'no pain' observers (see Table 4).

Table 4

Means and standard deviations of pain intensity ratings of different facial expressions

| | Observers | Pain intensity ratings | |
|-------------------------------|--------------|------------------------|-----------|
| | | <i>M</i> | <i>SD</i> |
| <i>Genuine expression</i> | Chronic pain | 3.87 | .35 |
| | No pain | 4.23 | .38 |
| <i>Exaggerated expression</i> | Chronic pain | 4.18 | .36 |
| | No pain | 4.86 | .39 |
| <i>Suppressed expression</i> | Chronic pain | 3.75 | .34 |
| | No pain | 3.68 | .37 |
| <i>Neutral expression</i> | Chronic pain | 2.08 | .25 |
| | No pain | .99 | .27 |

Discussion

The study demonstrated that observers struggled to distinguish between genuine, exaggerated and neutral facial expressions of pain. The pain condition of both the individuals displaying pain, and the individuals observing the expression, affected the ability to identify genuine and deceptive facial expressions. Images of individuals experiencing experimentally induced pain were easier to read than images of individuals experiencing chronic pain. Similarly, observers with no pain were better at discriminating between genuine and deceptive facial expressions, than observers with chronic pain. Observers' level of empathy had little effect on their ratings of the images' pain intensity. Observers' pain condition did have an effect on pain intensity ratings, where observers with chronic pain rated the pain intensity of images higher than did observers with no pain.

The first hypothesis, that observers would be able to distinguish between genuine, exaggerated and suppressed pain, was not supported. There were no differences between accuracy scores for genuine, exaggerated and suppressed facial expressions, suggesting that participants struggled to distinguish between facial expressions. Neutral expressions were correctly identified more often, with differences between accuracy scores for neutral expressions and genuine,

exaggerated and suppressed expressions. This shows that neutral expressions were clearer to read than genuine, exaggerated and suppressed expressions.

These results are in opposition to findings by Hadjistavropoulos et al. (1996) where observers were required to identify genuine, exaggerated and masked pain expressions of individuals experiencing chronic pain. Results showed that observers could accurately discriminate between these different pain expressions, where neutral and exaggerated expressions were best identified. It is important to note the differences between the current study, and that of Hadjistavropoulos et al. (1996). The most obvious difference is in the type of stimuli used. In Hadjistavropoulos et al. (1996), observers were shown dynamic film clips of pain expressions. In comparison, the current study used only still images of each expression, where there was no dynamic movement. While static portrayals of facial expressions are reliable sources of emotional information (Ekman & Friesen, 2003), they do not provide a complete account of the experience. As Ambadar, Schooler and Cohn (2005) demonstrated, subtle facial expressions were more readily identified when observers viewed dynamic versus static images. Ambadar et al. (2005) suggest that this may be due to the perception of change which is apparent in a dynamic facial expression. Thus, dynamic facial expressions may be more ecologically valid, as facial expressions in real life do not occur statically, and static images have lost a certain amount of salient emotional information.

Taken together, this may help to account for the differences seen between these two studies. As previous research has shown, dynamic displays are more robust examples of facial expressions (Atkinson, Dittrich, Gemmell, & Young, 2004). Consequently the results in Hadjistavropoulos et al. (1996) may be more reflective of an ecologically valid ability to discriminate between pain facial expressions. The lack of dynamic information in the current study may also have contributed to the weak accuracy scores found. Without dynamic cues relating to perception of change in the facial expressions, an important part of the pain information was lost, which may have influenced participants' ability to read the expression. This could have influenced their ability to discriminate between the genuine, exaggerated and suppressed pain expressions, resulting in weak accuracy scores. It is, however, important to note that participants in Hadjistavropoulos et al. (1996) were able to view each expression repeatedly, where participants in the current study viewed each expression only once. This is relevant, as the current findings may represent a more robust test of participants' ability to distinguish between genuine and deceptive facial expressions, as it involves their first impression, rather than a more effortful decision. Future recommendations would be that both static and dynamic expressions be included when studying discrimination accuracy of genuine and deceptive pain expressions. It would be useful to compare accuracy between these conditions, and to control the amount of time an expression is seen for.

The finding that neutral expressions were more easily identified than genuine, exaggerated and suppressed expressions, is in line with results from Hadjistavropoulos et al. (1996). It was suggested that neutral and exaggerated expressions are easier to identify, as they represent extremes of the characteristic pain face. Neutral expressions are an absence of features, and exaggerated expressions are over-expressions of pain (Hadjistavropoulos et al., 1996). This can be seen in the current results, which showed that neutral expressions were best identified. Exaggerated expressions also tended to be more accurately identified

than genuine and suppressed expressions, though this difference was small and non-significant. This finding can be linked to the lack of dynamic information, which may have played a role in observer's ability to accurately identify each expression. Nonetheless, the results support Hadjistavropoulos et al. (1996), in that extremes of facial expressions were more easily identified. Neutral expressions may also be easier to identify as they are not novel expressions, but rather are a common default expression on which other expressions are built. Tian, Kanade and Cohn (2001) suggest that neutral expressions are easier to identify, as they represent a lack of information, which is otherwise apparent in emotional expressions. Neutral expressions are thus more recognisable, as they are a common, default expression, with a characteristic lack of features.

The second hypothesis, that there would be a difference between accuracy scores for images of chronic pain, versus images of experimental pain, was supported. Images of healthy volunteers were more often correctly categorised (as genuine, exaggerated, suppressed or neutral pain expressions), than images of chronic pain sufferers. This suggests that genuine, exaggerated, suppressed and neutral facial expressions displayed by healthy volunteers were clearer and easier to read than those displayed by chronic pain sufferers. This has implications for health care professionals dealing with chronic pain sufferers. Littlewort et al. (2007) suggest that health care professionals report that facial expressions of pain are more informative than a patient's subjective report. Thus, it is particularly important that these professionals be able to accurately decipher when a patient, particularly one who is experiencing chronic pain, is hiding or exaggerating their pain. The results in the present study demonstrated that observers may not be able to accurately discriminate between genuine and deceptive pain expressions, an effect which is especially apparent in individuals experiencing chronic pain. Health care professionals therefore need to be aware that pain expressions may not always be the best indicator of subjective pain experience.

It is important to consider differences which exist between the facial expressions of pain in chronic pain sufferers and healthy controls. LeResche, Dworkin, Wilson and Ehrlich (1992) investigated facial expressions of patients with chronic pain, and found that the frequency of pain facial expressions increased with time. They suggest that pain facial expressions are subject to reinforcement, and eventually become chronic behaviours (LeResche et al., 1992). Hence pain facial expressions in chronic pain may be more akin to habitual behaviour, rather than a strong reaction to sudden, unexpected pain. With this in mind, different pain facial expressions in chronic pain may be underlined by a habitual pain facial expression, which influences the extent to which variations in the pain expressions are distinguishable. The present findings demonstrated this, as observers were poorer at distinguishing between different pain expressions of chronic pain volunteers versus expressions of experimental pain volunteers. In acute pain, there are no habitual pain expressions, and so variations in pain expressions may be more apparent, as they occur in isolation from any lingering pain expressions. Thus, in experimental pain, pain facial expressions were clearer than in chronic pain, as they were not underlined by baseline pain expressions. Moreover the current findings showed that observers were poorer at identifying neutral expressions of chronic pain volunteers, suggesting that even a lack of expression could be confused with pain expressions. This indicates that facial expressions in chronic pain may be shaped by previous experience with pain, agreeing with findings by LeResche et al. (1992).

Not only does previous pain experience influence individuals' baseline expressions, but it can also influence pain expressions through pain tolerance levels. Galin and Thorn (1993) investigated pain tolerance in genuine and deceptive facial expressions. Results showed that participants were more accurate when identifying pain expressions in individuals with low pain tolerance, versus in individuals with high pain tolerance. This suggests that pain tolerance can affect how pain signals are displayed in the face. The present findings showed that expressions of healthy volunteers were easier to read than those of chronic pain sufferers. Facial expressions may have been influenced by pain tolerance levels, where chronic pain sufferers had a higher pain tolerance, due to previous experience of severe pain, which is thought to increase pain tolerance levels (Dar, Ariely, & Frenk, 1995). Thus expressions of chronic pain sufferers may have been mediated by their pain tolerance levels, resulting in the poorer accuracy seen for distinguishing between genuine and deceptive facial expressions. Future research might explicitly investigate pain tolerance levels, to determine exactly how it interacts with pain experience, and the effect that this can have on pain expressions.

The third hypothesis, that there would be a difference between chronic pain and 'no pain' observers' accuracy in identifying genuine and deceptive pain expressions, was supported. Observers with no pain had higher accuracy scores in identifying genuine, exaggerated, suppressed and neutral pain facial expressions, than did observers with chronic pain. This shows that observers with and without chronic pain process pain-related stimuli differently, where 'no pain' observers are better at recognising variations in pain expressions. This is important as it demonstrates that having previous experience with pain can affect how pain-related stimuli is perceived and processed. The implications of these findings indicate that individuals without chronic pain are more reliable when discriminating between genuine and deceptive pain expressions. As such any individuals working with people in pain need to be aware of potential biases which their own pain experience brings. Even so, it is important to consider how having chronic pain can lead to these processing biases.

Individuals who are exposed to prolonged pain may experience cognitive and processing effects. As Pearce and Morley (1989) demonstrated, processing of pain-related stimuli is affected by prolonged exposure to pain. Hence previous experience with pain can lead to cognitive biases when processing pain-related information. Thus, as in the present study, individuals with chronic pain were poorer at recognising differences in pain expressions, due to a cognitive bias in processing pain-related information. Vervoort, Trost, Prkachin and Mueller (2013) investigated the effect of observers' personal experience with pain on attention, when viewing facial expressions of pain. Results showed that observers with more pain experience (chronic pain) showed decreased attention when viewing pain expressions, relative to neutral expressions (Vervoort et al., 2013). The present study agrees with Vervoort et al. (2013), as observers with chronic pain were poorer at distinguishing between pain expressions, indicating that their decreased attention affected processing of pain-related information. Vervoort et al. (2013) proposed that this may be due to an attempt to avoid the aversiveness of the pain expression, where chronic pain sufferers paid less attention to pain expressions, in order to avoid the emotional reactions which pain usually elicits.

Thus chronic pain sufferers' ability to detect variations in pain facial expressions was diminished. The present findings showed that, relative to observers' with no pain,

chronic pain observers were less accurate in distinguishing between genuine, suppressed and neutral facial expressions. It would be useful for future researchers to measure attentional processes of chronic pain sufferers and individuals with no pain, to establish precisely how this interacts with the ability to identify genuine and deceptive pain expressions.

The fourth hypothesis, that participants with high levels of empathy would rate the pain intensity of facial expressions higher than participants with low levels of empathy, was not supported. Pain intensity ratings of expressions were similar across high and low level empathisers. Therefore, observers' empathy levels had no effect on their pain intensity ratings of pain expressions. These findings contrasted against findings by Green et al. (2009), who found that high levels of empathy led to higher ratings of pain intensity. It is necessary to consider why these two findings are in disagreement.

Green et al. (2009) used only genuine pain expressions when investigating empathy and it may be that the different facial expressions influenced pain intensity ratings. It is important to consider such factors which may moderate empathy when viewing facial pain expressions. Hein and Singer (2008) suggest that feelings of empathy may be mediated by the intensity of the pain expression in others. Where pain expressions are more intense, observers tend to experience higher levels of empathy (Hein & Singer, 2008). In the present study, genuine, exaggerated, suppressed and neutral expressions represented different pain intensities, influencing pain intensity ratings over and above the effect of empathy levels. Thus the effects of empathy were outweighed by the extremes of high and low pain intensity expressions, which mediated participants' ratings. The present study therefore expands on Green et al. (2009) as it demonstrates that the effects of empathy can be influenced by the different pain expressions themselves. A recommendation would be to explicitly address how different expressions affect empathy, where the pain intensity of genuine and deceptive expressions may influence how empathic an observer feels towards someone in pain.

Results from additional analyses showed that the faces of individuals who were experiencing chronic pain, received higher pain intensity ratings than individuals experiencing experimentally induced pain. This shows that observers perceived chronic pain participants as experiencing more intense pain than participants experiencing experimentally induced pain. This may be an accurate reflection of the intensity of the pain experienced, where chronic pain participants rated their pain as more intense than experimental pain participants. Observers may have been recognising these differences without conscious awareness. Indeed Thibault, Loisel, Durand, Catchlove and Sullivan (2008) suggest that more severe and intense pain can lead to an increase in pain expression, where the expression intensifies to express the intensity of pain.

Additional analyses also showed that chronic pain observers rated neutral expressions as displaying higher pain intensity than did 'no pain' observers. This indicates that chronic pain observers were attributing more pain to resting faces than were 'no pain' observers. This can be linked to research suggesting that chronic pain sufferers have a bias towards pain-related stimuli, where their processing of information can be influenced by this attentional bias (Pearce & Morley, 1989; Pincus & Morley, 2001). Chronic pain observers may have had difficulties disengaging their

attention from expressions of pain, which in turn affected their judgements of neutral facial expressions. Thus, chronic pain observers may have attributed pain to expressions where there was none, because they were attentionally biased to pain. An implication of this finding is that having chronic pain can lead to a decreased ability to accurately interpret facial expressions of pain, and this can have an effect on how chronic pain patients interact with the people around them.

A major limitation is the exclusion of male participant facial expression data, due to insufficient numbers of male chronic pain sufferers being filmed. This gender bias is a reflection of the chronic pain population at large, (Breivik et al., 2006; Johannes et al., 2010). However it would be useful to include male participants in future studies, as research suggests that there are gender differences in pain expressions, where women are more expressive than men (Craig et al., 1991).

Another limitation regarding the filmed participants is the age difference between chronic pain and experimental pain participants. There was a significant age difference between these participants, and it was not possible to control for this in the final analysis of the survey results. Thus, future recommendations are to get a varied age range of both chronic pain and experimental pain participants, in order to rule out any effects of age on the ability to recognise different facial expressions of pain.

This study investigated genuine, exaggerated and suppressed facial expressions of pain, and showed that there are differences in how individuals with and without chronic pain display and perceive pain expressions. The present findings showed that observers struggled to distinguish between genuine and deceptive pain expressions. Nonetheless, observers were more accurate in categorising facial expressions from experimental pain participants than from chronic pain participants. Similarly, observers with no pain experience were more accurate than observers with chronic pain, in identifying genuine and deceptive expressions. Observers' empathy levels had no impact on their ratings of the pain intensity of each image. Thus, pain expressions are differentially processed by individuals experiencing chronic pain and individuals with no pain. Facial expressions of pain are essential to the communication of pain, and these findings suggest that individuals' previous experience of pain plays a major role in the communication of pain. This is especially important for niche populations who struggle with language, as a facial expression of pain may be the only way to communicate subjective distress. Health care professionals and carers need to be aware of those factors which can affect how pain expressions are displayed and perceived, where previous experience of pain can have profound effects on pain expressions. As shown here, pain expressions are influenced by various factors, and need to be recognised as complex indicators of subjective pain experiences.

References

Ambadar, Z., Schooler, J. W., & Cohn, J. F. (2005). Deciphering the Enigmatic Face: The Importance of Facial Dynamics in Interpreting Subtle Facial Expressions. *Psychological Science*, 16(5), 403–410.

- Atkinson, A. P., Dittrich, W. H., Gemmell, A. J., & Young, A. W. (2004). Emotion perception from dynamic and static body expressions in point-light and full-light displays. *Perception*, 33(6), 717–746.
- Breivik, H., Collett, B., Ventafridda, V., Cohen, R., & Gallacher, D. (2006). Survey of chronic pain in Europe: Prevalence, impact on daily life, and treatment. *European Journal of Pain*, 10(4), 287–287.
- Celik, K., Saritas, E., & Catalbas, G. (2013). The Effect of Student Teachers' Liking of Children and Empathic Tendency on the Attitudes of Teaching Profession. *International Journal of Science & Education*, 3(2), 499 – 510.
- Cleeland, C. S., & Ryan, K. M. (1994). Pain assessment: global use of the Brief Pain Inventory. *Annals of the Academy of Medicine, Singapore*, 23(2), 129–138.
- Craig, A. D. (2003). A new view of pain as a homeostatic emotion. *Trends in Neurosciences*, 26(6), 303–307.
- Craig, K. D., Hyde, S. A., & Patrick, C. J. (1991). Genuine, suppressed and faked facial behavior during exacerbation of chronic low back pain. *Pain*, 46(2), 161–171.
- Craig, K. D., Prkachin, K. M., & Grunau, R. E. (2011). The facial expression of pain. In D. C. Turk & R. Melzack (Eds.), *Handbook of pain assessment (3rd ed.)*. (pp. 117–133). New York, NY US: Guilford Press.
- Dar, R., Ariely, D., & Frenk, H. (1995). The effect of past-injury on pain threshold and tolerance. *Pain*, 60(2), 189–193.
- Darwin, C. (1998). *The expression of the emotions in man and animals*. Oxford University Press (Original work published 1872).
- Dworkin, R. H., Turk, D. C., Revicki, D. A., Harding, G., Coyne, K. S., Peirce-Sandner, S., & Melzack, R. (2009). Development and initial validation of an expanded and revised version of the Short-form McGill Pain Questionnaire (SF-MPQ-2). *PAIN*, 144(1–2), 35–42.
- Ekman, P. (1999). Basic emotions. In T. Dalgleish & M. J. Power (Eds.), *Handbook of cognition and emotion* (pp. 45–60). New York, NY, US: John Wiley & Sons Ltd.
- Ekman, P., & Friesen, W. V. (2003). *Unmasking the Face: A Guide to Recognizing Emotions from Facial Clues*. Los Altos: Malor Books.
- Ekman, P., Friesen, W. V., & Hager, J. C. (2002). *Facial Action Coding System*. Salt Lake City, UT.
- Ekman, P., Sorenson, E. R., & Friesen, W. V. (1969). Pan-Cultural Elements in Facial Displays of Emotion. *Science*, 164(3875), 86–88.
- Galín, K. E., & Thorn, B. E. (1993). Unmasking Pain: Detection of Deception in Facial Expressions. *Journal of Social and Clinical Psychology*, 12(2), 182–197.
- Gamsa, A. (1990). Is emotional disturbance a precipitator or a consequence of chronic pain? *Pain*, 42(2), 183–195.

- Goubert, L., D. K., Vervoort, T., Morley, S., L. M. J., de, A. C., & Crombez, G. (2005). Facing others in pain: The effects of empathy. *Pain*, *118*(3), 285–288.
- Green, A. D., Tripp, D. A., Sullivan, M. J. L., & Davidson, M. (2009). Relationship between empathy and estimates of observed pain. *Pain Medicine*, *10*(2), 381–392.
- Hadjistavropoulos, H. D., Craig, K. D., Hadjistavropoulos, T., & Poole, G. D. (1996). Subjective judgments of deception in pain expression: accuracy and errors. *Pain*, *65*(2–3), 251–258.
- Hadjistavropoulos, T., Craig, K. D., & Fuchs-Lacelle, S. (2004). Social Influences and the Communication of Pain. In T. Hadjistavropoulos & K. D. Craig (Eds.), *Pain: Psychological perspectives* (pp. 87–112). Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.
- Hager, J. C., & Ekman, P. (1983). The Inner and Outer Meanings of Facial Expressions. In J. T. Cacioppo & R. E. Petty (Eds.), *Social Psychophysiology: A Sourcebook*. New York: Guilford Press.
- Hein, G., & Singer, T. (2008). I feel how you feel but not always: the empathic brain and its modulation. *Current Opinion in Neurobiology*, *18*(2), 153–158.
- Hill, M. L., & Craig, K. D. (2002). Detecting deception in pain expressions: the structure of genuine and deceptive facial displays. *Pain*, *98*(1–2), 135–144.
- Hill, M. L., & Craig, K. D. (2004). Detecting deception in facial expressions of pain: accuracy and training. *The Clinical Journal Of Pain*, *20*(6), 415–422.
- Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005). How do we perceive the pain of others? A window into the neural processes involved in empathy. *NeuroImage*, *24*(3), 771–779.
- Johannes, C. B., Le, T. K., Zhou, X., Johnston, J. A., & Dworkin, R. H. (2010). The Prevalence of Chronic Pain in United States Adults: Results of an Internet-Based Survey. *The Journal of Pain*, *11*(11), 1230–1239.
- Kalisch, B. J. (1973). What Is Empathy? *The American Journal of Nursing*, *73*(9), 1548.
- Keefe, F. J., Williams, D. A., & Smith, S. J. (2001). Assessment of pain behaviors. In D. C. Turk & R. Melzack (Eds.), *Handbook of pain assessment (2nd ed.)* (pp. 170–187). New York, NY, US: Guilford Press.
- Larochette, A. C., Chambers, C. T., & Craig, K. D. (2006). Genuine, suppressed and faked facial expressions of pain in children. *Pain*, *126*(1–3), 64–71.
- LeResche, L., Dworkin, S. F., Wilson, L., & Ehrlich, K. J. (1992). Effect of temporomandibular disorder pain duration on facial expressions and verbal report of pain. *Pain*, *51*(3), 289–295.
- Littlewort, G. C., Bartlett, M. S., & Lee, K. (2007). Automated measurement of spontaneous facial expressions of genuine and posed pain. In *Faces of Pain*. Nagoya, Japan.

- Loeser, J. D., & Treede, R. D. (2008) The Kyoto protocol of IASP Basic Pain Terminology. *Pain*, 137, 473–477.
- Mehrabian, A. (1968). Some referents and measures of nonverbal behavior. *Behavior Research Methods & Instrumentation*, 1(6), 203–207.
- Merskey, H., & Bogduk, N. (1994) Classification of chronic pain. Seattle: International Association for the Study of Pain Press.
- Pantic, M., & Rothkrantz, L. J. M. (2000). Automatic analysis of facial expressions: the state of the art. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 22(12), 1424–1445.
- Pearce, J., & Morley, S. (1989). An experimental investigation of the construct validity of the McGill Pain Questionnaire. *Pain*, 39(1), 115–121.
- Pincus, T., & Morley, S. (2001). Cognitive-processing bias in chronic pain: A review and integration. *Psychological Bulletin*, 127(5), 599–617.
- Prkachin, K. M. (1992). The consistency of facial expressions of pain: a comparison across modalities. *Pain*, 51(3), 297–306.
- Prkachin, K. M. (2009). Assessing pain by facial expression: Facial expression as nexus. *Pain Research & Management: The Journal of the Canadian Pain Society*, 14(1), 53–58.
- Prkachin, K. M., Berzins, S., & Mercer, S. R. (1994). Encoding and decoding of pain expressions: a judgement study. *Pain*, 58(2), 253–259.
- Prkachin, K. M., & Solomon, P. E. (2008). The structure, reliability and validity of pain expression: Evidence from patients with shoulder pain. *PAIN*, 139(2), 267–274.
- Ruben, M. A., & Hall, J. A. (2013). “I Know Your Pain”: Proximal and Distal Predictors of Pain Detection Accuracy. *Personality & Social Psychology Bulletin*.
- Russell, J. A. (1994). Is there universal recognition of emotion from facial expressions? A review of the cross-cultural studies. *Psychological Bulletin*, 115(1), 102–141.
- Saarela, M. V., Hlushchuk, Y., Williams, A. C., Schürmann, M., Kalso, E., & Hari, R. (2007). The Compassionate Brain: Humans Detect Intensity of Pain from Another’s Face. *Cerebral Cortex*, 17(1), 230–237.
- Schiavenato, M., Byers, J. F., Scovanner, P., McMahon, J. M., Xia, Y., Lu, N., & He, H. (2008). Neonatal pain facial expression: Evaluating the primal face of pain. *PAIN*, 138(2), 460–471.
- Sengupta, S., & Kumar, D. (2005). Pain and emotion: relationship revisited. *German Journal of Psychiatry*, 8, 85–93.
- Shiel, W. C., & Stoppler, M. C. (2012). Pain (Chronic and Acute). *MedicineNet*. Retrieved November 10, 2013, from <http://www.medicinenet.com/script/main/art.asp?articlekey=40842>

- Spreng, R. N., McKinnon, M. C., Mar, R. A., & Levine, B. (2009). The Toronto Empathy Questionnaire: Scale Development and Initial Validation of a Factor-Analytic Solution to Multiple Empathy Measures. *Journal of Personality Assessment*, *91*(1), 62–71.
- Tan, G., Jensen, M. P., Thornby, J. I., & Shanti, B. F. (2004). Validation of the brief pain inventory for chronic nonmalignant pain. *The Journal of Pain*, *5*(2), 133–137.
- Thibault, P., Loisel, P., Durand, M. J., Catchlove, R., & Sullivan, M. J. L. (2008). Psychological predictors of pain expression and activity intolerance in chronic pain patients. *PAIN*, *139*(1), 47–54.
- Tian, Y.-L., Kanade, T., & Cohn, J. F. (2001). Recognizing action units for facial expression analysis. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *23*(2), 97–115.
- Van Hooft, S. (2003). Pain and communication. *Medicine, health care, and philosophy*, *6*(3), 255–262.
- Vervoort, T., Trost, Z., Prkachin, K. M., & Mueller, S. C. (2013). Attentional processing of other's facial display of pain: An eye tracking study. *PAIN*, *154*(6), 836–844.
- Wagner, H., & Lee, V. (1999). Facial Behaviour Alone and in the Presence of Others. In P. Philippot, R. S. Feldman, & E. J. Coats (Eds.), *The Social Context of Nonverbal Behavior* (pp. 262–314). Cambridge: Cambridge University Press.
- World Health Organisation. (2012). WHO Guidelines on the Pharmacological Treatment of Persisting Pain in Children with Medical Illnesses. Text. Retrieved November 10, 2013, from <http://www.ncbi.nlm.nih.gov/books/NBK138356/>
- Williams, A. C. de C. (2002). Facial expression of pain: An evolutionary account. *Behavioral and Brain Sciences*, *25*(04), 439–455.
- Williamson, A., & Hoggart, B. (2005). Pain: a review of three commonly used pain rating scales. *Journal of Clinical Nursing*, *14*(7), 798–804.