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Title: Investigating the Relationship Between Pain Indicators and Observers' Judgments of Pain

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Significance: Interpretation and assessment of pain remains one of the largest barriers to pain management and involves complex, idiosyncratic processing. This study provides insights into what information participants view as critical in making attributions of pain when presented with multiple, seemingly incongruent sources of information.

Introduction

Despite the clinical significance of pain, we still lack a robust understanding of how pain is best communicated to share this internal experience. Individuals living with chronic pain report disbelief or doubt concerning to the severity of their pain experience amongst the general public, intimate partners, friends, and family, in particular when causes of pain are not obvious to the eye or corroborated by medical evidence (Gibbons, 2000; Holloway et al., 2007; Meldrum et al., 2009; Tait et al., 2009; Toye & Barker, 2010; Monsivais, & Engebretson, 2012; De Ruddere et al., 2013; Newton et al., 2013). When attempting to assess or judge the pain experienced by others, we incorporate many sources of information. Martel and colleagues (2012) found that individuals who communicated pain non-verbally via facial expressions and protective pain behaviors, such as guarding, were judged to be in more pain than those who did not. Further, if individuals with pain do not show they are in pain or if no identifiable medical evidence was demonstrated, medically trained observers perceive them negatively and rate their pain intensity as low (Twigg et al., 2015). The existing literature highlights that multiple sources of information can be used to influence judgements of pain in others and complications may arise when integrating information, especially when it is inconsistent (e.g., high medical evidence with low pain behaviors). As a result of the biomedical model that we typically encounter when seeking treatment, individuals may prefer to base their judgement on measures of pain they falsely believe to be objective and unambiguous by measuring pathophysiological parameters associated with pain (e.g., X-ray, Magnetic Resonance Imaging (MRI), computed tomography (CAT), heart rate variability, skin conductance, etc.) (Cowen et al., 2015).

In support of this assumption, it has been repeatedly shown that "objective" scientific data influences the judgement of pain levels and disability by members of the general public and medically trained persons (Tait et al., 1994; Chibnall et al., 1995; Chibnall et al., 1997;

Tait et al., 2009; De Ruddere et al., 2013; De Ruddere & Craig, 2016). Specifically, these studies revealed that when medical evidence is lacking, there seems to be a tendency to discount pain and rate the individual as emotionally distressed. This suggests that visual displays summarizing medical technology that falsely appear to quantify pain objectively, such as graphs (e.g., pain stimulus intensity) or scientific images (e.g., brain activation), might be strongly influential when evaluating another's pain. However, a tendency to rely on perceived "objective" measures to estimate pain is problematic given that pain is per definition a subjective perception, self-report is the gold standard for pain measurement, and these so called "objective" measures (e.g., brain imaging, stimulus intensity, etc.) are no more objective metrics of the pain experience than self-report (Raja et al., 2020).

In light of the anecdotal tendency to prefer perceived objective sources of evidence, paired with the problems inherent to such 'objective' sources, it is important to examine more closely how lay people integrate multiple sources of information when they judge the severity of pain in others that they may be caring for, socializing with, or working alongside. Narrative analysis of individuals and children living with chronic pain indicate that isolation from their peers was a common theme (Meldrum et al., 2009), and isolation can be perpetuated by loss of relationships as a result of pain disbelief (Newton et al., 2013). In order to project legitimacy of their illness during social interactions, individuals with chronic pain report the need to outwardly appear in pain, while also balancing this perception with not appearing "too ill" (Toye & Barker, 2010). As chronic pain is a personal experience impacted by social factors (Raja et al., 2020), the social and interpersonal context will influence both the judgements made about another person's pain and the impact that the judgment has on the person living with chronic pain. However, this study aims to first address this novel question by exploring which of a range of potential cues (depictions of sensory input, brain activation, self-reported pain depicted on a numeric rating scale (NRS), and facial expressions) participants are most influenced by when making attributions of pain or pain intensity in an unfamiliar person. Our working hypothesis was that the participants would base their assessment primarily on pain indicators like the severity of the injury (here represented by a visual display of the intensity of the applied noxious stimulus) or a measure of physiological response (here represented by brain activation maps), as the existing literature suggests these visual displays of technology falsely appear to quantify pain objectively, while self-report ratings or pain behaviours may be discounted when conflicting information is present.

Methods

Participants and Demographics

Data was collected between October 2018 and April 2019. 60 participants were recruited from the general population through Mechanical Turk (23 women, 36±10 years old). In order to be included, all participants were required to be 18 years of age or older and report proficiency in English comprehension (59 participants were fluent, 1 had acceptable proficiency). Only individuals with a Mechanical Turk account (MTurk; crowdsourcing website for individuals to perform discrete tasks, such as surveys), from primarily English-speaking countries, and a Human Intelligence Task (HIT) approval rate (the proportion of completed tasks that are approved by survey requesters) of at least 90% were invited to participate in the study. Participants were compensated 2 dollars for taking part in the study. The study was approved by the University of Reading Ethics Committee, and informed consent was obtained from all participants according to the revised Declaration of Helsinki (2013).

Sources of Pain Indicators

Participants underwent two forced choice tasks with different pain indicators described below. Fig. 1 provides examples of each type of pain indicator used for both a high and low pain level.

INSERT FIGURE 1

Selection of Stimuli. Images from the UNBC-McMaster shoulder pain expression archive database were selected for this study to depict nonverbal pain communication (Lucey et al., 2011). Prior to the primary study, we conducted an online survey of 73 participants asking participants to rate the level of pain depicted in facial expression images (Appendix S1). We only included images that we had confirmed to be rated by untrained participants as either low in their expressions of pain (rated as 0-3 out of 10) or high (rated as 5-10 out of 10) (see section "Identification of Pain Facial Expressions" in Appendix S1).

In order to obtain images of brain activation corresponding to the pain intensity of the selected faces, the mean ratings and standard deviations for facial expressions were matched with pain ratings in unpublished brain activation data of 39 healthy adults who underwent functional magnetic resonance imaging (fMRI) while rating the pain experienced from a range of thermal stimuli (44–49 °C; see Johnstone et al., 2012 for methods). Axial slices (z=0, Montreal Neurological Institute (MNI) coordinates) of human brain activation maps in response to painful heat stimulation were selected to represent a biological indicator of pain.

In order to obtain temperatures corresponding to the pain intensity of the faces and brain activation images, we selected the average temperature needed to elicit pain ratings mapping on to the chosen brain activation images and pain intensity ratings taken from the unpublished brain activation data. These pain indicators were rounded to a whole number and used to generate temperature graphs representing the severity of the applied pain stimulus. A higher change in temperature on this graph – starting from a baseline of 43°C – indicated a greater input received by the patient. Variance of these stimuli was then simulated using the standard deviations of temperature ratings.

To create visual analogue scales representing self-reported pain, each centimetre on a 0-10cm scale represented one point on the scale. We used the mean and standard deviation of pain facial expression ratings to create self-report stimuli. The mean rating of low pain facial expressions was used to create low self-report indicators, adding or subtracting the standard deviations from the mean to simulate variance in the stimuli, marking the horizontal line with a vertical red line representing the pain rating. This process was identical for high indicators.

Facial expressions. Participants were instructed that "People experiencing pain often make characteristics facial expressions. We photographed participants while they were experiencing various levels of heat pain. The face on the left shows an expression usually associated with high pain, the face on the right shows an expression usually associated with low pain." Heat pain was fictitiously indicated in the vignette as we intended the four indicators (pain facial expression, brain activation, sensory input, and self-report) to appear to be taken from the same hypothetical individuals, and sensory input is represented by heat stimulus. Participants were then given exemplar images for high and low pain indicators as seen in Fig. 1.

Brain activation. Participants were instructed, "People experiencing pain often display characteristic patterns of activation in MRI studies. The brain indicator shows you their brain's responses to the thermal stimuli. On the right you see a pattern of activation usually observed when someone is experiencing high pain and on the left you see a pattern of activation usually observed when someone is experiencing low pain." Participants were then given exemplar images for high and low pain indicators as seen in Fig. 1.

Sensory input. A line graph was created in Microsoft Excel depicting the physical input, or more specifically, the temperature (in degrees Celsius) supposedly applied to the patient's upper arm. Participants were instructed "People experiencing high temperatures often experience pain. The stimulus indicator shows you the temperature of the heat stimulus. On the left image you see a high temperature, usually associated with pain, on the right image you see a low temperature usually associated with low pain." Participants were then given exemplar images for high and low pain indicators as seen in Fig. 1.

Self-report pain ratings. Visual analogue scales were created in Microsoft Paint to present participants with the patients' fictitious self-report of pain. High pain ratings were depicted with a small vertical red line going through a 10 cm long black horizontal line toward the right end of the NRS where "most pain imaginable" was indicated. For ratings indicating low pain, the red line crossed the black horizontal line closer to the left end where "no pain" was indicated. Participants were instructed the following, "People experiencing pain often rate their pain on a numeric rating scale. We asked people to rate the amount of heat pain they experienced on a 0-10 scale where 0 is "no pain" and 10 is "the most pain imaginable". On the left you will see a rating usually associated with high pain and on the right you will see a rating usually associated with low pain." Participants were then given exemplar images for high and low pain indicators as seen in Fig. 1.

Experimental Procedures

Participants gave informed consent and were asked to provide their demographic information. They were then introduced to each type of pain indicator that would be used in the study (sensory input, brain activation, self-reported pain depicted on a NRS, and facial expressions), showing examples of low and high pain for each indicator. Once participants were familiarized with the task material, they commenced the pain judging tasks (see details below).

Who is in more pain? (Task 1): Task 1 included 24 trials in total and took approximately 15 minutes. Pain indicators of two different (fictional) patients were presented in randomized order in a two alternative forced choice task. Participants were asked to judge the pain of these fictitious patients with chronic pain, instead of acute pain that may be experienced in daily life, because the experience of chronic pain is frequently questioned and doubted without clinical evidence of physical damage as a source of pain. This study was developed to specifically assess which indicators of pain information are most influential on judgment of chronic pain by the general population. For each pair of fictitious patients, two pain indicators (using either the same or different types of indicators) were shown to the participants, who were asked to assess which patient was in more pain. Trials included comparisons of all four pain indicators (facial expressions, sensory input, brain activation, and self-report) at both pain levels (high or low pain) occurring twice, resulting in 12 trials for each pain level. Here, we were particularly interested in congruent pain level indicators (e.g., two indicators of high pain), as these trials would reveal which indicator type would most influence participants decision. All trials included comparisons of unique stimuli for each condition. Manipulation checks were performed to ensure indicators putatively representing different levels of the same indicator were perceived as such (i.e., high face indicators were rated as more painful than low face indicators; Table S2).

Task 1 Analysis. When congruent pain level stimuli were presented, responses can be interpreted as the indicator participants believe to be a more salient reflection of pain. To assess which pain indicators participants selected most with congruent pain intensities (e.g., high pain facial expression and high brain activation), a nonparametric Friedman test was conducted. Post-hoc Wilcoxon signed-rank tests were carried out in the case of significant main effects to evaluate which type of pain indicator was selected most frequently by participants for congruent high pain intensities and congruent low pain intensities. To facilitate the estimation of confidence intervals for each effect, the data were bootstrapped using the Monte Carlo method, with a confidence level of 99% and 10,000 iterations.

Following this, Hodges-Lehman estimations were completed to calculate 95% confidence intervals for the data. Significance levels were set to $p < .05$.

How much analgesia does this patient need? (Task 2)*:* Once completed, participants were asked to take a break before starting Task 2, which entailed 48 trials and took approximately 20 minutes to complete. To examine the influence of pain indicators when given incongruent pain intensity indicators for a single patient, the participants' task was to indicate on an eleven-point numeric rating scale, ranging from 0g to 10g, in increments of 1g how much analgesic cream they would prescribe to a hypothetical patient who indicated pain (see Fig. 2). To describe the patient's pain, two different pain indicator types were provided in randomized order displaying both incongruent and congruent information (e.g., high pain self-report and a low pain facial expression). Every combination of pain level (low vs high) and indicator (facial expressions, sensory input, brain activation, and self-report) occurred twice, excluding presentations of the same stimulus (i.e., high face and high face) resulting in 24 trials at incongruent pain levels. Trials of interest included those with incongruent information. Manipulation checks using congruent information were implemented within the task to ensure that participants perceived indicators as the intended level of pain (i.e., for congruent high pain indicators, participants should prescribe high analgesic cream) (Table S3 & S4).

INSERT FIGURE 2

Task 2 Analysis: In incongruent trials in Task 2, higher amounts of analgesic cream prescribed indicated a stronger influence of the high pain indicator, while lower scores indicated a stronger influence of the low pain indicator. To assess which indicator is more influential when different indicators give conflicting information (e.g., high pain facial expression and low brain activation), a repeated measure analysis of variance (ANOVA) was conducted. The mean number of grams prescribed in the following experimental situations was calculated:

1) High facial expression with low brain activation, low sensory input, or low self-report.

2) High sensory input with low facial expression, low brain activation, or low self-report.

3) High brain activation with low facial expression, low sensory input, or low self-report measure.

4) High self-report measure with the low facial expression, low sensory input, or low brain activation.

Parallel analysis was performed for low pain indicators (a combined total of analgesic medication for each low pain indicator and the three other high pain indicators). Pairwise comparisons were conducted to evaluate which type of high pain indicator was prescribed the highest amount of analgesic cream and which type of low pain indicator was prescribed the lowest amount. Significance levels were set to $p < .05$.

Subjectivity vs. Objectivity Task. Finally, participants were presented with one example of each pain indicator type again and were asked to indicate whether they would categorize them as an objective or subjective measure of pain. For each indicator participants had to indicate via forced choice whether they classified it as objective, subjective, or neither. Neither was included as a response option because it is possible the latent model of subjectivity/objectivity for participants may be uncertain (e.g., participants who are aware that temperature is objective measure, but not an objective measure of pain). Before commencing this final task of the experiment, we provided participants with brief definitions of 'objective' and 'subjective'. *Objective* was defined as "information that is not influenced by personal feelings or opinions in representing facts" (Oxford University Press,2019a).

Subjective was defined as "information that is based on or influenced by personal feelings" (Oxford University Press,2019b).

Results

Participant Demographics

A majority of our participants were white (52 white, 5 black/African/Caribbean, 2 Asian, and 1 Latin) and had a high school diploma/A-Levels (27 high school diploma/A-levels, 24 undergraduate University degree, 8 postgraduate University degree, 1 secondary school diploma/GCSE).

Task 1: Judging Congruent High Pain Indicators

The Friedman test showed that there was a statistically significant difference in participants' preferences when presented with two congruent high pain level indicators, ($\chi 2(3) = 57$, $p < .001$). The median interquartile range (IQR) of the number of times an indicator was selected and provides a rank to compare each indicator. Results indicated participants selected self-report most and facial expression least (facial expressions (0; 0-1), sensory input (1.5; 1-2), brain activation (2; 1-3), and self-report indicators (2; 2-3). To formally test differences between individual indicators, post hoc analysis with Wilcoxon signed-rank tests was conducted. There were no significant differences between brain activation and sensory input ($Z = -1.148$, $p = .251$, 95% CI [0, 0.5]) or between self-report and brain activation ($Z = -1.172$, $p = .241$, 95% CI [-0.5,0]). However, significant differences were found indicating that participants relied on self-report more than on sensory input (Z = -2.470, p = .013, 95% CI [0, 1]) and less upon facial expression indicators than all other stimuli: sensory input ($Z = -5.662$, $p < .001$, 95% CI [1,1.5]), self-report ($Z = -5.788$, $p < .001$, 95% CI [1.5, 2]), or brain activation indicators ($Z = -5.142$, $p < .001$, 95% CI [1, 2]). Results are depicted in Fig. 3A.

Task 1: Judging Congruent Low Pain Indicators

The Friedman test showed that there was a significant difference in participants' preference when presented with congruent low pain level indicators, ($\chi 2(3) = 46.444$, $p < .001$). The median IQR for number of selected indicators indicated participants selected sensory input most and facial expression least (facial expressions (1; 0-2), sensory input (3; 2-3), brain activation (1; 1-2), and self-report indicators (2; 1-2). There were no significant differences between self report and brain activation ($Z = -1.286$, $p = .198$, 95% CI [-1,0]) or brain activation and facial expressions ($Z = -1.575$, $p = .115$, 95% CI [0,0.5]). However, significant differences were found, indicating that participants relied more upon sensory input than facial expressions ($Z = -5.079$, $p < .001$, 95% CI [1, 2]), self-report than facial expressions ($Z = -2.688$, $p = .007$, 95% CI [0,1]), sensory input than brain activation ($Z = -4.628$, $p < .001$, 95% CI [1,2]), and sensory input than self-report ($Z = -4.366$, $p < .001$, 95% CI [0.5,1.5]). Results are depicted in Fig. 3B.

INSERT FIGURE 3

Task 2: Analgesic Cream Prescribed for the High Pain Indicators

The analysis was performed to determine which indicator influenced participants' decision on the amount of analgesic cream they would prescribe to the fictive patient when multiple sources of information are available. An influential high pain indicator would increase the amount of analgesic cream. For instance, a participant who relies heavily on brain activation may select a high dose of analgesic cream when presented with a high pain brain activation and a low facial expression. The repeated measures ANOVA revealed a significant difference in the number of grams prescribed by participants when presented with incongruent pain indicators, $F(3, 177) = 14.143$, $p < 0.001$. Pairwise comparisons were conducted to evaluate which type of high pain indicator was prescribed the highest amount of analgesic cream in the presence of a low pain indicator. Self-report was the most influential ($M = 5.52$, $SD = 1.67$) when compared to high brain activation ($M = 4.80$, $SD = 1.95$, p =

.013), high sensory input (*M* = 4.94, *SD* = 1.83, *p* = .008), and high pain facial expressions (*M* = 4.04, *SD* = 1.82, *p* < .001). Facial expressions (*M* = 4.04, *SD* = 1.82) were the least influential pain indicator when compared to sensory input (*M* = 4.94, *SD* = 1.83, *p* < .001), brain activation (*M* = 4.80, *SD* = 1.95, *p* < .001), and self-report measures (*M* = 5.52, *SD* = 1.67, *p* < .001). There was no significant difference in the respective influence of brain activation (*M* = 4.80, *SD* = 1.95) and sensory input (*M* = 4.94, *SD* = 1.83, *p* = .587). Results are depicted in Fig. 4A.

Task 2: Analgesic Cream Prescribed for the Low Pain Indicators

The analysis was performed to determine and rank which low pain indicator influenced participants' decision to prescribe analgesic cream to the fictive patient. An influential low pain indicator would lower the amount of analgesic cream. For instance, a participant who relies heavily on brain activation may select a low dose of analgesic cream when presented with a low pain brain activation and a high facial expression. The repeated measures ANOVA revealed a significant difference in the number of grams prescribed by participants when presented with incongruent pain indicators, $F(3, 177) = 11.288$, $p < 0.001$. Pairwise comparisons were conducted to evaluate which type of low pain indicator was prescribed the lowest amount of analgesic cream in the presence of a high pain indicator. Consistent with findings in the analysis of high pain indicators, pairwise comparisons showed self-report to be most influential, as indicated by lower scores (*M* = 4.30, *SD* = 1.80) when compared to low brain activation (*M* = 4.82, *SD* = 1.90, *p* = .042), low sensory input (*M* = 4.68, *SD* = 1.70, *p* = .044), and low pain facial expressions (*M* = 5.50, *SD* = 1.70, *p* < .001). Again, facial expressions (*M* = 5.50, *SD* = 1.70) were the least influential in comparison to sensory input (*M* = 4.68, *SD* = 1.70, *p* < .001), brain activation (*M* = 4.82, *SD* = 1.90, *p* = .002), and self-report measures (*M* = 4.30, *SD* = 1.80, *p* < .001). There was no significant difference in the respective influence of brain activation (*M* = 4.82, *SD* = 1.90) and sensory input (*M* = 4.68, *SD* = 1.70, *p* = .519). Results are depicted in Fig. 4B.

INSERT FIGURE 4

Perceptions of Subjectivity and Objectivity

Participants were asked to rate each type of indicator as objective, subjective, or neither. Consistent with expectations, more participants considered brain activation and sensory input as objective and facial expressions as subjective. Surprisingly, more participants considered self-report as an objective measure. Results of this task can be found in Table 1.

Discussion

Previous literature indicates that when participants integrate multiple sources of information, they favor pain indicators perceived, although often falsely, to be objective (e.g., scientific visual displays) and discount pain behaviors and indicators perceived as subjective. In our data, facial expression indicators were perceived as subjective and were the least likely, among all pain indicators, to influence observer's judgements of pain. In contrast, self-report indicators had the greatest influence on participants judgements about how much analgesic cream to prescribe and were perceived as objective by half of participants.

Perceptions of Objectivity and Self-Report Indicators

Although more participants rated the brain activation and sensory input as objective than the self-report measures, the self-report measures, which are truly a subjective indicator, were perceived as objective by half of participants. Regarding the perceived objectivity of self-report, it is possible participant's responses indicated a belief that self-report provides direct insight into the patient's pain, as opposed to indirect information via sensory input or brain activation. Therefore, participants could use these ratings to compare it to their own pain experiences and understand the patient's pain more easily than via the other indicators

(Giordano et al., 2010; Prkachin et al., 2001). It is also possible that participants perceived the numeric representation of self-report as an objective source of information, perhaps being perceived as more objective than other kinds of self-report rating scale (e.g., likert).

It has been repeatedly shown that the presence or absence of 'objective' medical evidence influences the judgement of pain levels and disability by the general public and medically trained persons (Tait et al., 1994; Chibnall et al., 1995; Chibnall et al., 1997; Tait et al., 2009; De Ruddere et al., 2013; De Ruddere & Craig, 2016). However, in the presence of a high pain self-report measure and another low pain indicator, participants were more likely to prescribe a greater amount of analgesia. In the presence of a low pain self-report measure and another high pain indicator, participants were more likely to prescribe a low amount of analgesic cream. A possible explanation for the discrepancy between our findings in the general public and previous findings in clinical staff is that the latter may routinely make judgements about pain that carry more risk (e.g., prescribing narcotics or supporting disability claims), which may induce a more generally sceptical attitude towards self-reported pain. Consistent with this interpretation, Tait and colleagues (2016) found that participants from the general population were more likely than physicians to rely on self-report measures of pain intensity when deciding whether to prescribe opioids or file a disability claim for a patient. Previous literature suggests that perceptions of objectivity and subjectivity likely play a role in how an individual determines what information to rely upon when making judgements about pain. However, due to the categorical nature of the present data, we were unable to assess the moderating influence of objectivity/subjectivity on the judgements made using different sources of pain information. Future research should seek to examine how perceptions of objectivity/subjectivity moderate the relationship between different types of pain information and judgments of pain.

Reliance on Medical Evidence with Ambiguous Information

As expected, participants relied upon visual displays of technology that summarize the severity of the injury (i.e., intensity of the applied noxious stimulus) or a measure of physiological response (i.e., brain activation maps), more frequently than the indicator rated as most subjective (i.e., facial expressions) when pain was low. Other studies have found that in the presence of low pain and medical evidence, physicians were more likely to augment the amount of pain they perceived in the patient relative to the patient's self-report of pain (Chibnall et al., 1997). The presence of medical evidence provides a pathological explanation for pain and corroborates the patient's reported symptoms. Many studies have found strong evidence of observers discounting patient's pain when ratings are high and in the presence of symptom uncertainty (Tait et al., 2009). In this case, the indicators perceived to be objective may provide more certainty about the existence of pain and worked to validate the patient's symptoms to a larger extent by oversimplifying the ambiguity of the pain experience. Despite methodological advancements, measures often perceived to be "objective", such as brain imaging techniques, are still insufficient in providing certainty about pain experiences and chronic pain syndromes (Davis et al., 2012; Davis et al., 2017). Nevertheless, this interpretation is supported by results from a related field which has demonstrated that pictures showing brain activation to support (fictional) scientific findings can influence people in judging the accuracy of the presented data (McCabe et al., 2008). In their experiments, McCabe and colleagues varied the type of images they showed in support of research articles presented to the participants: no image, a bar graph, or a topographical map of brain activation. The articles rated as most scientifically sound and accurate were the ones that included a topographical map of brain activation, suggesting that images of brain activation help persuade people to believe otherwise intangible information – they seem to make abstract processes and constructs more concrete and provide the participant with heuristics to make rapid decisions (McCabe et al., 2008).

Distrust of Facial Expressions

Face indicators were the least likely to influence observer's judgements of pain among all pain indicators and were perceived as subjective. Martel, Thibault, and Sullivan (2011) investigated the importance and influence of pain behaviors in observers' judgements of pain intensity and genuineness among 90 undergraduate psychology students. Participants were asked to watch videos of chronic pain patients and to make inferences about the patients' pain intensity and degree of faking. The results demonstrated that participants relied heavily on the patients' facial expressions when making judgements about pain intensity and genuineness compared to protective pain behaviors (i.e., guarding). One possible explanation for why the findings in the present study are supposedly inconsistent with the findings by Martel and Colleagues may be that participants consider it possible to fake facial expressions and therefore do not trust them as an indicator in comparison to the indicators perceived as being more objective, but they may also believe pain behaviours such as guarding are even more possible to fake than facial expressions, as found by Martel and colleagues. An alternate, more methodological explanation is that a still image of a facial expression may be perceived as more ambiguous than a dynamic facial response sequence would be. The idiosyncratic nature of a complex experience like pain means that emotions are hard to decipher, with some patients looking like they are smiling versus others that are grimacing. Future studies should test these possibilities by comparing short video clip of pain behaviours to similar clips of other pain indicators (e.g., dynamic brain responses or temperature changes). The available face stimulus set also did not provide ample variance in the sex, race, cultural backgrounds, and age demographics in order to examine the impact of these variables on judgments of pain, which future research should seek to examine. In addition, the current study did not collect a pain history for participants which could influence interpretations of pain information. For instance, participants who have previously utilized self-report in a clinical environment to communicate their pain experience may consider self-report to be a more objective indicator of pain than those without chronic pain history. Future studies could examine group differences in pain judgements between those with chronic pain and those without.

Conclusion

Interpretation and assessment of pain remains one of the largest barriers to pain management, and it involves complex and, often, idiosyncratic processing. Understanding how we evaluate pain when presented with multiple, often seemingly incongruent sources of information, remains a critical challenge to understanding biases and instances of inaccurate assessment. We found that in situations where incongruent information was presented about an individual's pain, participants relied on the pain indicators that they perceived to be objective. Counterintuitively, this included self-report (putatively, the most subjective of the indicators presented). Due to pain's subjective nature, self-report is still considered the gold standard measure of pain. Nevertheless, there is extensively documented mistrust of self-report in many clinical settings. Further research is needed to determine whether the discrepancy between our results and these observations is a function of a higher level of perceived risk (of medication or compensation seeking) in those clinical settings. In addition, the present study did not assess the effect of previous experience with pain symptoms, social and relationship context, and sociodemographics, such as gender or age of the individually making pain judgements, on which indicators are the most influential for making pain judgements. These important factors may influence experience with indicators, such as self-report rating scales and brain images, and future research should seek to assess their influence.

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Figure 1. Examples of stimuli used across experiments: (**A**) high pain facial expression, (**B**) low pain facial expression, (**C**) high pain brain activation, (**D**) low pain brain activation, (**E**) high pain sensory input, (**F**) low pain sensory input, (**G**) high pain self-report, (**H**) low pain self-report.

Figure 2. Example of a Task 2 incongruent pain trial judging a low pain self-report and a high pain brain activation.

Figure 3. A) The mean number of times each high pain indicator was selected in the presence of another high pain indicator. Greater scores indicate greater influence of the indicator. B) The mean number of times each low pain indicator was selected in the presence of another low pain indicator. Greater scores indicate greater influence of the indicator. The line inside box indicated median, x inside box indicated mean, lower and upper error lines respectively indicate 10th and 90th percentiles, filled circles represent individual data points. Due to the discrete nature of data for the judging congruent indicator task, a count of participant responses is included next to each filled circle. *p < 0.05; **$p < 0.01$; ***$p < 0.001$

Figure 4. A) The mean number in grams of analgesic cream prescribed in the presence of incongruent pain. Each type of high pain indicator was presented with a low pain indicator (e.g., high pain facial expression and low self-report measure). Greater scores indicate greater influence of the indicator. B) The mean number in grams of analgesic cream prescribed in the presence of incongruent pain. Each type of low pain indicator was presented with a high pain indicator (e.g., low pain facial expression and high self-report measure). Lower scores indicate greater influence of the indicator. *p < 0.05; **p < 0.01; ***p < 0.001

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FIGURE 1

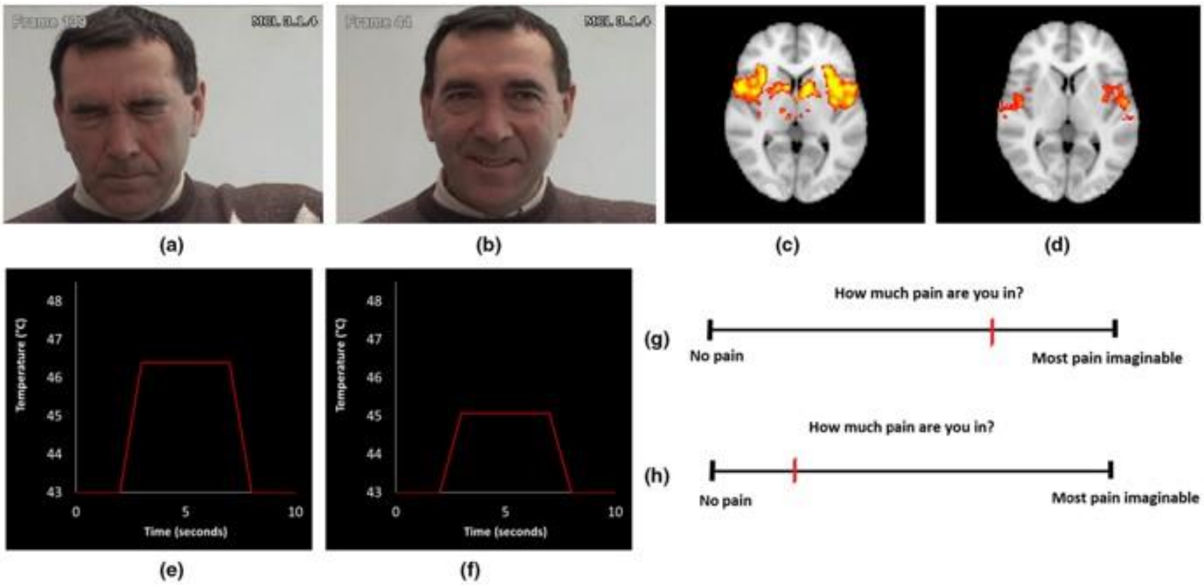

(a)
(b)
(c)
(d)
Temperature (°C)
48
47
46
45
44
43
0
5
10
Time (seconds)
(e)
(f)
How much pain are you in?
(g)
No pain
Most pain imaginable
How much pain are you in?
(h)
No pain
Most pain imaginable

FIGURE 2

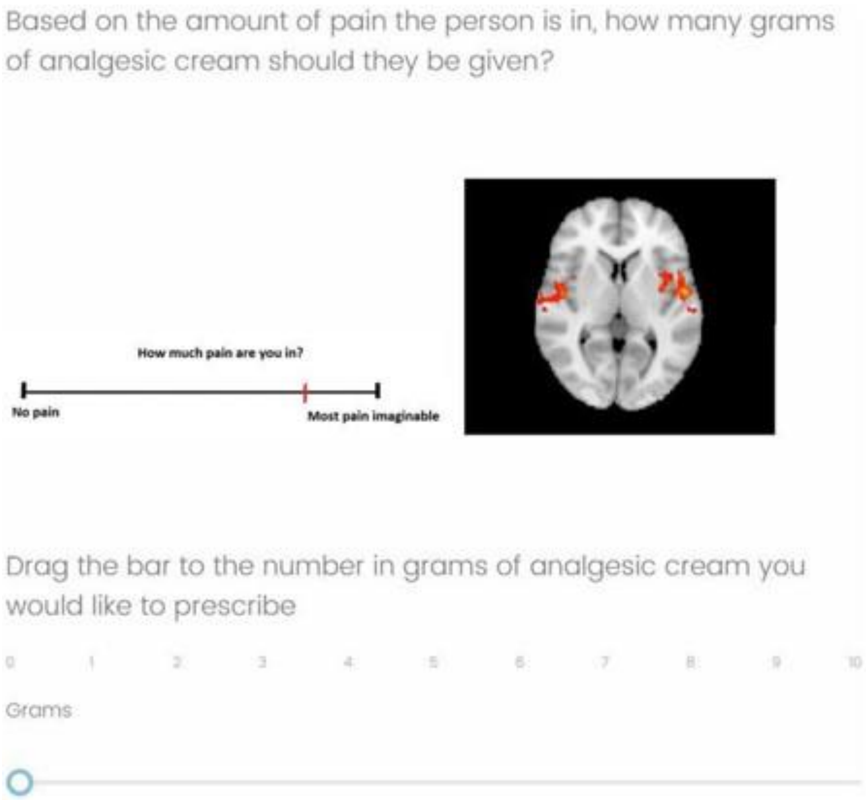

Based on the amount of pain the person is in, how many grams of analgesic cream should they be given?
How much pain are you in?
No pain
Most pain imaginable
Drag the bar to the number in grams of analgesic cream you would like to prescribe
0 1 2 3 4 5 6 7 8 9 10
Grams

FIGURE 3

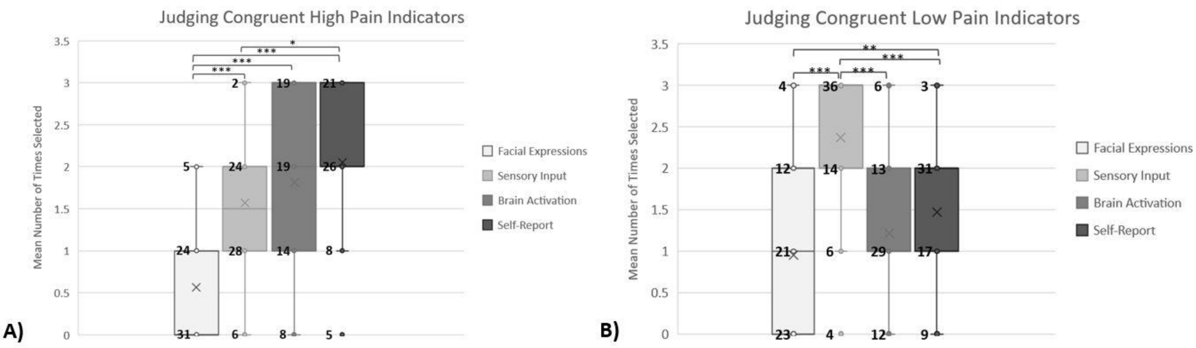
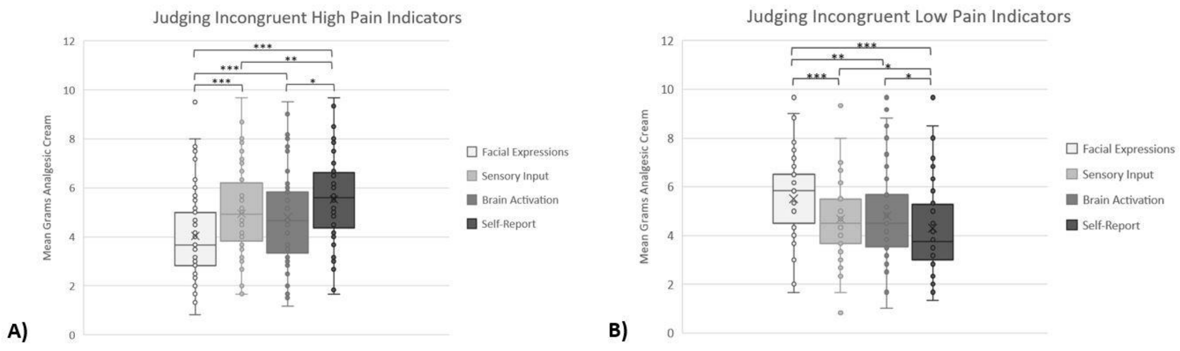

Judging Congruent High Pain Indicators
Mean Number of Times Selected
Facial Expressions
Sensory Input
Brain Activation
Self-Report
A)
Judging Congruent Low Pain Indicators
Mean Number of Times Selected
Facial Expressions
Sensory Input
Brain Activation
Self-Report
B)

FIGURE 4


Judging Incongruent High Pain Indicators
Mean Grams Analgesic Cream
Facial Expressions
Sensory Input
Brain Activation
Self-Report
A)
Judging Incongruent Low Pain Indicators
Mean Grams Analgesic Cream
Facial Expressions
Sensory Input
Brain Activation
Self-Report
B)