Perspective-taking influences attentional deployment towards facial expressions of pain: An eye-tracking study

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Abstract

Empathetic perspective-taking (PT) may be critical in modulating attention and associated responses to another's pain. However, the differential effects of imagining oneself to be in the pain sufferer's situation ('Self-perspective') or imagining the negative impacts on the pain sufferer's experience ('Other-perspective') on attention have not been studied. The effects of observer PT (Self vs. Other) and level of facial pain expressiveness (FPE) upon attention to another person's pain was investigated. Fifty-two adults were assigned to one of three PT conditions; they were instructed to view pairs of pain expressions and neutral faces and either 1) consider their own feelings (Self-perspective), 2) consider the feelings of the person in the picture (Other-perspective), or 3) received no further instructions (Control). Eye movements provided indices of early (probability and duration of first fixation) and later (total gaze duration) attentional deployment. Pain faces were more likely to be fixated upon first. A significant first fixation duration bias towards pain was observed, which increased with increasing levels of FPE, and was higher in the Self-PT than the Control condition. The proportion of total gaze duration on pain faces was higher in both experimental conditions than the Control condition. This effect was moderated by FPE in the Self-PT condition; there was a significant increase from low to high FPE. When observers attend to another's facial display of pain, top-down influences (such as PT) and bottom-up influences (such as sufferer's FPE) interact to control deployment and maintenance of attention.

Keywords: Pain, empathy, perspective-taking, attention, eye-tracking

Introduction

Pain serves an adaptive function by signaling threat and capturing attention, which likely instigates protective behaviors. Pain may likewise serve protective functions within the interpersonal context [49,52] by capturing others' attention, which is considered critical in motivating observer concern and approach behavior [9,36,37]. However, observing others in pain may also signal a threat to observers *themselves* [26,39,40,46], motivating observer avoidance behavior when perceived threat to the self is too high [5].

While a number of variables may modulate observer attention and associated caregiving responses to another's pain, research suggests that observer *perspective-taking* (PT) may be critical in this regard. Indeed, the capacity to take the perspective of another person ('Other-perspective'), and to differentiate it from one's own ('Self-perspective') [30,32,35], increases empathic concern resulting in a response attuned to the pain sufferers` needs [3,23,30,32,33,34]. Conversely, imagining oneself to be in the pain sufferer's situation ('Self-perspective') may give rise to self-oriented aversive emotional responses that enhance perceived threat value of pain and levels of personal distress [8,30,32,33,34], resulting in less adaptive caregiving behaviour [5,24]. However, how the adoption of the Self or the Other perspective impacts *attention to another person's pain* has yet to be investigated. This is critically important as the engagement of the observer`s attention is likely key in driving caregiving behaviour, and hence, constitutes a key target for intervention [6,10,53,59].

Accordingly, we sought to examine the role of observer PT (Self vs. Other) in attention deployment towards varying levels of facial pain expressiveness (FPE). Facial expressions are specifically adapted for social communication [9,11,45,59] and provide a key channel through which to communicate the experience of pain to others [42,58]. Eye-tracking technology has been employed to assess attention to others' pain, facilitating the direct and continuous tracking of attention [16,17] . Research has demonstrated that when pain and neutral facial expressions are presented, observers are more likely to fixate on pain [27], and that greater pain expressiveness induces faster detection [53] and longer gaze duration [28].

The current study allowed replication of these earlier findings and an examination of the moderating role of FPE level in understanding the impact of observer PT upon observer attention to another's pain. We hypothesized that 1) observers would allocate more attention to pain faces compared to neutral faces, both at early stages (probability of first fixation; first fixation duration) and later stages (total gaze duration) of attentional processing. We further hypothesized that 2) observer exposure to PT instructions, compared to no instructions, would increasingly bias attention towards pain faces. Drawing on findings indicating that increasing levels of personal distress and perceived threat are particularly prevalent when a Self-perspective is taken [30,32] we expected this effect to be most pronounced within the Self-perspective condition. Further, given increasing levels of FPE are likely to increasingly demand attention [e.g., 28,53], we explored 3) whether increasing FPE would moderate (e.g., strengthen) the observed effects.

Methods

Design

A 3 x 3 mixed factorial design was employed with a PT Instruction condition (Self PT condition, Other PT condition, and Control condition) as a between participant factor and Facial Pain Expressiveness (Low, Moderate, or High Facial Pain Expressiveness (FPE)) as a within participant factor. The effects of PT on attention allocation to painful facial expressions, and the moderating role of level of FPE were investigated. Prior to the eye tracking viewing task, participants completed a Cold Pressor Task (CPT). PT (Self-, Other-, or Control) was experimentally evoked (see the viewing task and perspective-taking manipulation section).

A Cold Pressor Task (CPT) was used in all three conditions (see Cold Pressor Task section) to create context for the experimental manipulation – the experience of pain empathy. Prior to participation in the CPT, participants were informed that, during the eye-tracking task, they would view pictures of facial expressions of others who had reacted to the same painful task; this information was referred to in the PT instructions (see Appendix A). The CPT and associated information on observed facial expressions were included because previous research suggested that people tend to have greater empathetic concern for those who have been through similarly distressing experiences [59,60,61]. At the same time, pictures were also made personally relevant for observers themselves [54]. The importance of the observer's personal pain experience as a contextual variable has previously been highlighted by Vervoort et al. [53] . Hence, the purpose of including this task was to specify the characteristics of the pain experience to be in line with the target for empathy (Self or Other perspective).

Sample and Participants

An a priori power analysis was conducted, using G*Power [18], to identify the number of participants required to estimate the interaction effect between perspective-taking and FPE on pain bias. The following assumptions were employed: effect size = .25, p value = .05, power = .8, number of groups = 3. The total sample required was 36. Sixty psychology students were recruited via SONA, an online internal university research participation system. Each participant was carefully screened to ensure that they were healthy and pain-free at the time of participation. Exclusion criteria were any pre-existing medical condition that could contribute to altered pain perception (i.e., cardiovascular disease, hypertension, the use of related medication, Reynaud's syndrome, or recent injuries) (see Figure 1 for a Flowchart Diagram illustrating the decision-making rationale). Eligible participants were randomly assigned to one of three PT conditions: Self PT condition (N = 16), Other PT condition (N = 19), or Control condition (*N* = 17). Data from the total of 52 psychology students aged between 18 and 46 years (*M* = 22.21, *SD* = 6.92), were analysed in this study.

Undergraduate students were given course credits in exchange for their participation. Descriptive statistics of the sociodemographic characteristics are displayed in Table 1. Ethical approval was granted by the NUI Galway Research Ethics Committee.

[INSERT FIG. 1 HERE]

[INSERT TABLE 1 HERE]

Self-report Measures

Interpersonal Reactivity Index Perspective Taking Scale

Following the approach taken elsewhere [32], the Interpersonal Reactivity Index [IRI;12,13] was administered to assess individual differences in dispositional empathy. Although the instrument contains four seven-item subscales (perspective taking, empathic concern, personal distress, and fantasy), with each of the scales tapping a separate facet of empathy, we only used the Perspective Taking (PT) scale. The perspective taking (PT) scale measures the tendency to adopt the point of view of others. Items are rated on a 5-point Likert Scale ranging from 0 (“Does not describe me well”) to 5 (“Describes me very well”). The subscale scores range from 0 to 28 and it has previously been shown to have good reliability, construct validity and internal consistency (PT *a* = 73) [12,14]. In our sample, internal consistency for the subscale was *a* = .68. As in Lamm et al. [32], the initial intention was to include only participants who had an IRI PT score of at least 11. This was the case for all but the one participant who scored 10 on the PT subscale of IRI. The forthcoming analyses was conducted with and without the participant. As the results were not affected, a decision was made to include this participant`s data in the analyses reported here.

Pain Tolerance

The length of time for which a participant was willing to keep his or her hand submerged in the water, indicating the maximum level of pain that a person was able to tolerate, was taken as a measure pain tolerance. Following the approach in previous studies, the latencies to the intolerable pain was measured with a stopwatch in seconds [e.g., 31].

Viewing task and Facial Pain Expressiveness stimulus materials

A stimulus set consisting of 32 pain and neutral facial expressions were permitted for use by Vervoort et al. [53]. This set consists of pictures of 8 adult faces (4 males, 4 female) with Neutral Facial Pain Expressions (NFPE) and simulated expressions of pain at three different levels of intensity: Low (LFPE), Moderate (MFPE), and High (HFPE) Facial Pain Expressiveness (Fig. 2). This resulted in a series of 24 possible neutral-pain face combinations (i.e., NFPE paired with LFPE, MFPE, or HFPE), which then doubled to 48 trials when the order of each stimulus position was counterbalanced for left- and right- side presentation of the pain face. There was an equal chance of a pain face occurring on the left- or right-hand side of the screen. Details of the development and validation of this stimulus set have been described elsewhere [53].

[INSERT FIG. 2 HERE]

Eye movement measurement

An eye-tracking device was used in order to track eye movement and foveal fixation during the viewing task. The eye-tracking device used was the EyeLink® 1000 Plus Desktop Mount (version 5.03; SR Research Ltd., Ottowa, Ontario, Canada). This is a video-based eye-tracker with a high spatial resolution (<.01° RMS) and a sampling rate of 1000Hz. Viewing was binocular, but only the most dominant eye was monitored. This approach was taken as Nyström et al. [38] found that dominant eyes are tracked more accurately, they produce significantly less offset than nondominant eyes. Position accuracy ranged from 0.25° - 0.5°. The tracker was placed on the desk beneath the computer screen. A chin and forehead rest were used at a height level to the screen, in order to stabilize the head at a constant distance (approx. 70 cm) from the screen and to minimize head movements. Eye-movements were monitored via the reflection of infrared light on the cornea and the pupil, which is sensed by the tracker. This information was then analysed to extract real-time estimates of eye-rotations. Corneal and pupil thresholds were calibrated for each participant.

Cold Pressor Task

A Cold Pressor apparatus consisted of an 18-litre insulated water-bath, paired with a combination of cooling units. The Cold Pressor Task (CPT) involved placing a non-dominant hand into the cold-water bath, which was maintained at a constant 4 °C (±1 °C), for a maximum duration of five minutes. Following the guidelines for use described by Von Baeyer et al. [55], participants were not told exactly how long to keep their hand immersed for, in order to account for individual differences in pain tolerance [1,15]. Rather, they were told to keep their hand immersed in the water tank to just above the wrist for "*as long as they can bear it*". They could take their hand out at any time when it became too unbearable and if they still had their hand in at the 5-minute mark, they were asked to terminate the task immediately. The cold-water was circulated continuously by a pump attached to a water-bath in order to ensure consistency in temperature [15]. This procedure is commonly used within pain management research [22,29,55,57] and temperatures between 1°C and 5°C have been deemed painful but safe for adult use within this context [1,15].

Viewing task and perspective-taking manipulation

Participants were informed that picture pairs of people who had taken part in the "cold-water task" would be presented on a computer screen. Carefully designed and standardized instructions were used to increase the interpersonal relevance of stimulus material. Specifically, participants were told that the pictures in the viewing task had been taken while other people were undergoing the same "cold-water task", which they themselves had just completed. Further task instructions differed upon random condition assignment. The instructions for PT conditions were developed based on those used by Batson et al. [4]. In the Self PT condition, participants were both verbally, and then through written instructions displayed on a computer screen, encouraged to concentrate on their own emotional response and imagine how they themselves would be affected by doing the painful “cold-water task” *(“While you are viewing the pictures, try to imagine how* ***you*** *yourself would* ***feel*** *about what is happening. Concentrate on how* ***you*** *would feel while doing the painful cold-water task and how* ***you*** *would* ***be affected by it****. Imagine* ***your own emotional response*** *as you would experience the pain”).* In contrast, participants in the Other-perspective condition were encouraged to concentrate on imagining the other person’s emotional response as he/she would have experienced the pain *(“While you are viewing the pictures, try to imagine how* ***the people you see feel about what is happening.*** *Concentrate on how* ***the person*** *feels while doing the painful cold-water task and how* ***he/she*** *is affected by it. Imagine that person`s emotional response as* ***he/she*** *experiences the pain”).* In the control condition, no additional instructions were provided (see Appendix A for exact scripts used). Participants read the above instructions with certain words bolded and underlines. This measure was taken to emphasise and to increase the chances that participants will pay attention to the core aspects of the instructions.

Prior to the viewing task, a brief test was performed to ascertain each participant’s dominant eye, as it was tracked in the study. Next, the calibration procedure was performed to relate eye gaze and screen positions. As described above, a set of standardised verbal and written instructions regarding the viewing task were provided, including a printed example display of the facial stimuli to be used within the trials. This was done in order to increase participant familiarity with the demands of the experimental viewing task in advance. As an additional prompt, specific PT instructions were provided again on screen for each participant at the beginning of the viewing task. Participants were told that, during the viewing task, they could look anywhere on the slides while the pictures were being presented, but to focus on a white fixation cross when presented in between each slide.

Participants then completed the experimental viewing task, in which 48 slides displaying facial stimuli were presented while movements of the dominant eye were measured. Each trial began with a drift-correction check on a blank grey screen. Once the experimenter confirmed the absence of drift, a white fixation cross was presented in the centre of the screen for 1500ms, and then a slide with the facial stimuli for a further 3000ms. The viewing task consisted of 48 trials, with each of the possible neutral-pain face combinations (i.e., NFE paired with LFE, MFE, or HFE) being presented twice to ensure that the order of each stimulus position was counterbalanced for left- and right- side presentation of the pain face.

Two manipulation checks were performed, which allowed researchers to screen for participants who had not adhered to the specific experimental instructions (Self-, Other-, or none) during the viewing task (e.g., due to lack of understanding). The first manipulation check was performed after verbally introducing instructions, where participants were asked to use an a web-based questionnarire in order to respond to the following: *"The instructions which you have just been provided have been specifically designed to ensure that everyone taking part in this experiment approaches the next viewing task in the same way. Before we proceed, please type in your understanding of these instructions in the space provided below".* The second manipulation check was performed immediately after the viewing task and, following the approach taken in previous research [4,48], participants were asked to specify the self – reported perspective they had adopted while viewing the slides. Specifically, with the use of three items, particiapnts were asked to assess (a) the extent to which they tried to imagine what the depicted person might be thinking, feeling, and experiencing; (b) the extent to which they tried to imagine what they themselves might be thinking, feeling, and experiencing; and (c) the extent to which they tried to be objective and emotionally detached. These ratings were made on 7-point scales ranging from 0 ("not at all") to 6 ("very much so"). As each participant was asked to rate the items within the context of their assigned condition, and after they had been introdcued to specific perspective-taking instuctions (if any), the task allowed to identify a discrepency between the allocated and the self-reported perspective that had been taken.

Procedure

Participants were informed that researchers were interested in how facial expressions of pain in others are attended to. After providing informed consent, participants were asked to complete the CPT, followed by the completion of a computerised questionnaire (demographic and self-report measures). Next, participants completed the viewing task. Participants were seated in a windowless room with standardized overhead lighting for the duration of this task. A researcher sat behind a screen during the viewing task. After the viewsing taks, participants completed the second maniulation check. Afterwards, all participants were fully debriefed. The whole experiment lasted for approximatelly 45 minutes.

Eyetracking outcomes

Data analysis was based on the eye movements recorded within two areas of interest (AOI) presented on the left- and right-hand side of the screen. Each AOI contained one of the two target pictures (i.e., a pain or neutral facial expression) presented in each trial. Each AOI was rectangular, 10 cm in length by 16 cm in height, and positioned 11 cm apart (5.5 cm from the centre of the screen). Fixations were defined using a combined velocity and acceleration algorithm [47]. Three parameters were then calculated for each AOI in each trial: 1) Probability of First Fixation, 2) Duration of First Fixation, and 3) Total Gaze Duration. All analyses were conducted in R [43]. Two participants were excluded from Total Gaze Duration analyses, since they had fewer than 20 trials with a Total Gaze Duration in both AOIs over 1500ms (less than 50% of viewing time in the face AOIs).

Probability of First Fixation

"Probability of First Fixation" was defined as the likelihood that attention would be allocated to the pain or the concurrently displayed neutral face first within each trial (i.e., the probability of a first fixation within either AOI).

First Fixation Duration

"First Fixation Duration" was defined as the duration (in ms) of the first fixation that each participant made for each type of facial expression. It provided a second index of early attention allocation, as most First Fixation Durations did not exceed 500ms. First fixations in the Pain and Neutral AOIs were included if they occurred no earlier than 100ms prior to the faces being presented in these AOIs. For data analysis, pain bias was estimated by contrasting the first fixations in each AOI and deriving the proportion of first fixation time allocated to the Pain AOI. This proportion estimated the attentional bias towards pain faces induced by FPE or PT.

Total Gaze Duration

"Total gaze duration" was defined as the duration of time (in ms) spent on each face within a trial. In each trial, faces were presented for a maximum of 3 seconds, during which time participants could attend freely to either face type. As described above for First Fixation Duration, we derived the proportion of Total Gaze Duration in the Pain AOI of the Total Gaze Duration spent in both AOIs. Total Gaze Duration arguably index voluntary/ later allocation of attention, rather than involuntary/ early attentional processes measured by the foregoing measures [13].

Data Analysis

The use of generalized linear models has previously been recommended as the most appropriate statistical approach for studying inter-individual differences in visual attention [8,44]. Binomial GLMs were used to analyse the Probability of First Fixation and proportions of First Fixation Duration and Total Gaze Duration in the Pain AOI. Proportions of time were employed to deal with the fact that, within a trial, First Fixation Durations and Total Gaze

Duration in the Pain AOI were necessarily dependent on First Fixation Durations and Total Gaze Duration in the Neutral AOI and vice versa, since time in one AOI reduced the time available to spend in the other.

Given that each participant was exposed to all levels of facial FPE, random intercepts were included for Participant and FPE and a random slope was included for FPE within Participant. In all three models, attention towards the pain stimulus was predicted by PT and FPE and their interaction. Both predictor variables had three levels (Control, Self, and Other PT and Low, Moderate, and High FPE) and orthogonal contrasts estimated the effects of these variables. For PT, the effects of Self PT and Other PT Instructions were compared with the Control condition; for FPE, the effects of Moderate and High FPE were compared with Low FPE. In models of First Fixation Duration and Total Gaze Duration, a Pain First variable was also included to control for the effects of entering the Pain AOI first on the relative time spent in both AOIs (Pain First was True if the Pain AOI was the first AOI entered in a trial). This control was included because (a) both First Fixation Duration and Total Gaze Duration are measures of the duration spent in a specific AOI and entering an AOI first increases the potential duration in that AOI and (b) participants were, on average, more likely to enter the Pain AOI first in a trial.

Results

Probability of First Fixation

The probability that the first fixation of a trial would occur in the Pain AOI provided an index of observer initial attentional deployment. In the current study, the probability that pain faces were fixated first (.55) was significantly higher than chance (*OR* = 1.22, $p < .0005$, 95% CI = 1.12-1.33; Fig. 3). The mean difference in the probability of first fixating on a pain face or neutral face per participant was approximately 10% (*M* = .0997, 95% CI = 0.0601-0.1420). There were no main effects of PT or FPE on Probability of First Fixation and no interaction effects (all *ps* > .2; see Table 2 and Fig. 3). Since participants were significantly more likely to enter the Pain AOI first, a Pain First variable was included in the remaining analyses to control for effects on pain bias in First Fixation Duration and Total Gaze Duration.

[INSERT TABLE 2 HERE]

[INSERT FIG. 3 HERE]

First Fixation Duration

Pain bias in First Fixation Duration was estimated by contrasting the first fixations in each AOI and deriving the proportion of first fixation time allocated to the Pain AOI. The effects of FPE (Low FPE vs Moderate FPE; Low FPE vs High FPE) and PT (Control vs. Self, Control vs. Other) and their interactions were estimated using binomial mixed effects model. A Pain First variable (entering the Pain AOI first within a trial) was also included as a covariate. As can be seen in Table 3, there were no significant interactions between PT conditions and FPE. Of the main effects, the significant intercept (OR = 1.11, p < .001) indicates that First Fixation Duration in the Pain AOI was longer than in the Neutral AOI on average within a trial indicating a significant first fixation duration bias towards pain. Findings further indicated that Self PT Instructions (OR = 1.18, p = .024) significantly increased First Fixation Duration in the Pain AOI relative to the Control condition, but Other PT instructions did not (OR = 1.11, p = .126). A permutation test indicated that there was no significant difference in pain bias between PT conditions (p = .23). FPE increased pain bias, with both Moderate FPE (OR = 1.11, p = .025) and High FPE (OR = 1.24, p <.001) inducing significant increases in pain bias relative to Low FPE. A paired t test indicated that there was no significant difference in pain bias between Moderate and High FPE, $t(50) = -1.93$, p = .059. The effect of the Pain First control variable was also significant; entering the Pain AOI first in a trial significantly reduced pain bias (OR = .87, p < .001). This was because First Fixation Duration in the first AOI visited in a trial were shorter (M = 250ms) with less variance (SD = 176ms) than first fixations in the second AOI visited in a trial (M = 280ms, SD = 240ms). In Fig. 4, we present the mean ratios of Pain/Neutral durations of first fixations for all nine conditions. Increases in First Fixation Duration due to FPE are quite apparent, especially the effects of viewing High FPE faces. The effects of Self PT Instructions on First Fixation Duration are less pronounced.

[INSERT TABLE 3 HERE]

[INSERT FIG. 4 HERE]

Total Gaze Duration

Similarly, to the previous analysis, we estimated Pain Bias values based on the relative Total Gaze Duration in the Pain AOI and the Neutral AOI within each trial. A binomial mixed model estimated the effects of PT and FPE and their interactions controlling for Pain First on Total Gaze Duration in the Pain AOI as a proportion of Total Gaze Duration in both AOIs. Trials in which participants spent a total of less than 1.5 seconds of the available 3 seconds in the AOIs were excluded and the results of two participants were excluded due to retaining too few trials following these exclusions.

As can be seen in Table 4, an interaction between PT and FPE was observed. Specifically, the effect of Self PT on the ratio of Total Gaze Duration on pain faces was significantly moderated by High FPE (OR = 1.35, p=.007). That is, in the Self PT condition, the increase in pain Total Gaze Duration from the Low FPE condition to the High FPE condition was significantly greater than in the control condition. PT did not affect the increases in Total Gaze Duration due to viewing Moderate FPE faces rather than Low FPE faces. Significant main effects were observed for all predictors. Total Gaze Durations were longer in the Pain AOI on average within a trial (OR = 2.18, $p < .001$). Self PT (OR = 1.85, $p < .001$) and Other PT (OR = 2.15, p<.001) significantly increased Total Gaze Duration in the Pain AOI relative to the control condition, but there was no significant difference in pain bias between PT conditions ($p = .43$). FPE also increased Total Gaze Durations in the Pain AOI, at both the Moderate FPE (OR = 1.17, $p < .001$) and High FPE levels (OR = 1.3, $p < .001$) compared to Low FPE, but there was no significant difference in pain bias between Moderate and High FPE, $t(49) = -1.59$, $p = .118$. Entering the Pain AOI first in a trial significantly increased Pain Total Gaze Duration (OR = 1.15, $p < .001$). In Fig. 5, we present the mean ratios of Pain/Neutral Total Gaze Duration for all nine conditions. For all conditions, Total Gaze Durations in the Pain AOI were considerably greater than in the Neutral AOI. Both PT conditions induced further strong increases in the Total Gaze Durations in the Pain AOI and FPE effects were stronger in the PT conditions than in the Control condition.

[INSERT TABLE 4 HERE]

[INSERT FIG. 5 HERE]

Discussion

The study aimed to examine the role of observer PT (Self vs. Other) and the moderating effect of sufferer's level of FPE (low, moderate, high) on observer early and later attentional processing of another's pain. Findings can be summarized as follows. First, we identified attentional biases towards others' pain, both at early and later stages of attentional deployment. Specifically, facial expressions of pain were more likely to be fixated first, relative to the neutral expressions. Furthermore, the durations of first fixations on painful facial expressions were also longer, compared to neutral expressions. Regarding attentional maintenance, expressions of pain were also attended to for longer than neutral expressions. Second, the degree of pain expressed on the observed face (FPE) increased the pain biases in First Fixation Duration and Total Gaze Duration, but did not increase the probability of fixating first on a pain expression. In particular, intensity of expressed pain (FPE) influenced first fixation durations to pain, with moderate and high FPE being associated with enhanced First Fixation Durations pain bias, relative to low FPE. The level of expressed pain (FPE) also impacted Total Gaze Duration such that allocated attention was longer on the painful facial expressions, and again longer at the moderate and high FPE levels, compared to low FPE. Third, the current findings also attested to the role of observer PT in understanding observer attention to another's pain. Specifically, imagining how oneself would feel (Self PT) increased First Fixation Durations bias towards painful facial expressions, compared to observers who received no instructions. This effect was not observed amongst the Other PT condition. However, the overall Total Gaze Duration bias towards facial expressions of pain among the Self PT condition, as well as those in the Other PT condition, were longer relative to the Control condition.

The current findings are, to the best of our knowledge, the first to demonstrate that bottom-up characteristics (e.g., FPE), top-down variables (e.g., PT), as well as the interaction between both are important in understanding observer attention to anothers' pain. However, this was *not* the case at the very early stages of observer attention deployment. In particular, low facial pain displays were sufficiently but also, as compared to higher facial pain displays, equally capable of engaging observers' attention. Furthermore, whether observers imagined themselves or the other experiencing pain or having received no specific instructions, did not impact whether pain was attended to first. These findings likely have a common evoluationary ground as it may be more adaptive to first scan for the presence/absence of threat-relevant information in the environment, before evaluating how safe/unsafe this signal appears to be. The initial and quick localization may facilitate the conscious and later assessment of danger severity.

Our findings demonstrated that, once a pain expression has been fixated, PT and the degree of pain implied by the expression impacts attention. In particular, this study is one of the first to demonstrate that First Fixation Durations increase with increasing levels of FPE. It seems that, in certain contexts, the increased threat value of pain observed in others hampers observers' ability to disengage from such pain expressions from the very first moment pain is attended to. Total Gaze Duration was also influenced by FPE and in a similar direction, with longer periods of attention allocated at moderate and high pain expressiveness levels. These findings provide further support for the delayed disengagement hypothesis [19], which posits that once a threatening stimulus has been attended to, it is more difficult to disengage attention [56].

The current study provides preliminary evidence that higher-order cognitive processes may affect early attentional processes that are typically assumed to be basic and stimulus driven. Specifically, participants who were asked to imagine the pain they saw as their own (`Self-perspective`) demonstrated longer First Fixation Durations, compared to observers who received no instruction. This effect was further enhanced by higher levels of FPE. In contrast, observers in tn the ‘Other-perspective` condition did not fixate initial gaze for longer than those in the Control condition. Drawing upon personal pain literature [30,32,52], it is plausible that imagining how oneself would feel in painful situations induces self-oriented aversive emotions (e.g., personal distress) and this, in turn, increases hypervigiliance to pain stimuli at the early stages of attentional processing [30,32]. Importantly, the effects of complex higher-order social constructs on relatively low level processes is not without precedent in the literature [20] and concepts of social status were demonstrated to influence perceptual categorisation of faces on a racial continuum from black to white [20,21].

During later attentional maintenance, exposure to both the Self and the Other PT instructions increased proportion of Total Gaze Durations on facial pain expresions, compared to the Control condition. In addition, the increase in Total Gaze Duration from low to high FPE in the Self PT condition was higher than in the control condition. This increase, relative to control, was not significant in the Other PT condition (p = .08), but it was in the same direction. The significant increase from low to high FPE in the Self PT condition (see Fig. 5) was facilitated by lower Total Gaze Durations in the low FPE condition, relative to the Other PT condition, since the proportion of Total Gaze Duration on high FPE faces was similar for both perspective-taking conditions. This might indicate that the Other PT condition induced an “all or none” approach to voluntary attentional deployment, or possibly that following the Other PT instruction was more complex, which induced greater Total Gaze Duration on lower FPE faces while participants engaged these processes. In contrast, Self PT was more sensitive to varying levels of facial pain expressiveness, perhaps due to being a simpler imitative process [3,8,33,34]. These interpretations are necessarily tentative at this point, but it is clear that perspective-taking instructions strongly influence voluntary attention.

While the current findings suggest that PT is critical in understanding observer attention to others’ pain, with Self PT mostly involved across all stages of attention deployment, there are several questions that remain to be addressed. First, while attention is considered critical in helping behavior, it remains to be assessed how the current findings would translate into actual behavioral responses, and in relevant populations (e.g., caregivers). Drawing upon the broader empathy literature, it is likely that taking the Other-perspective while witnessing pain may evoke empathic concern and more altruistic response [3,4,50]. In contrast, using a Self-perspective may induce personal distress and lead to a more self – centred aversive emotional response [3,34]. Although Self-perspective has been associated with reduced perceptual accuracy in detecting distress in others [25], these effects remain to be explored in the context of pain. Second, while we observed higher levels of attention allocation in the Self vs. Control condition across all stages, we captured attention for a brief period of time (3s) and it cannot be ruled out that the increased attention bias observed in the Self PT condition could eventually result in attentional avoidance tendencies occurring later in time.

The present study made numerous practical compromises that might be addressed in future studies. First, although eye-tracking offers the distinct advantage of measuring attention as a continous process that changes over time, this method relies on the assumption that eye movements accurately reflect visual attention [16,41]. Gaze behavior does not necessarily always reflect covert attentional processes, which may still occur elsewhere even in the presences of overt eye movements [17,41,53]. A more active viewing paradigm, which includes additional response requirements (e.g., using mouse tracking methodology) may help to evaluate how meaningful detected attentional biases are in terms of their subsequent implications on pain-related behavior. Secondly, one might consider employing different stimuli to increase ecological validity. Specifically, the current study employed static images and simulated facial expressions of pain. Future studies might employ videos of dynamically evolving authentic facial expressions of pain. Third, future studies might assess the attentional effects of pain expressions in potentially relevant populations (e.g., caregivers of those with chronic pain) to explore whether the effects observed here are moderated by subject variables. Assessing the attentional pain biases of participants with experience of pain might be particularly appropriate given the potential role that attention allocation might play in facilitating or obstructing therapeutic approaches. The interaction between dispositional empathy and empthy induced by perspective-taking instructions is also worthy of investigation. Finally, further research could also examine whether the observed effects are specific to pain or generalize to other negative states, such as anger or fear.

Despite these limitations, the findings of the current study provide important information regarding how pain faces are selectively processed when PT are employed in a sample of the general population. The effects of PT on later attentional processes were strong and clear [7], with some evidence of an enhancement of the effects of pain-related facial features. We also documented significant effects of Self PT on early attentional allocation towards painful expressions. Further research is needed to examine suggested potential mechanisms (e.g., self-oriented vs. other-oriented emotions) driving these attentional biases and elucidate to what extent attention bias to sufferer pain are relevant in understanding caregiver behaviour.

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Figures Legend

Fig. 1: A flowchart diagram of participants exclusion with the decision making rationale.

Fig. 2: An example of possible neutral-pain face combinations (Left-Right).

Fig. 3: Pain Bias in Probability of First Fixation.

Fig. 4: Pain Bias in First Fixation Duration.

Fig. 5: Pain Bias in Total Gaze Duration.

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Table 1: Descriptive statistics of sociodemographic variables

Table 2: Probability of First Fixation

Table 3: Duration of First Fixation

Table 4: Total Gaze Duration

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Figures Legends

Fig. 1. A flowchart diagram of participants exclusion with the decision making rationale.

Fig. 2. An example of possible neutral-pain face combinations (Left-Right).

Fig. 3. Pain Bias in Probability of First Fixation. Dots denote the mean probability of fixating on the control or pain face first during a trial and error bars denote bootstrapped confidence intervals.

Fig. 4. Pain Bias in First Fixation Duration. The plot depicts mean Pain Bias in durations of first fixations across participants for all three levels of Pain Expressiveness in three Instructions conditions. Pain Bias scores were calculated as the within-trial ratio of Pain:Neutral duration of first fixations. Consequently, at 1.2, the Pain:Neutral ratio was 1.2:1 meaning first fixations on Pain faces were were 1.2 times longer than on Neutral faces. When the ratio was 1 (dotted line), first fixations for pain and neutral faces were the same duration. Trials in which either AOI was skipped were not included in these estimates. Error bars denote bootstrapped confidence intervals.

Fig. 5. Pain Bias in Total Gaze Duration. The plot depicts mean Pain Bias in Total Gaze Duration across participants for all three levels of Pain Expressiveness in three Instructions conditions. See Fig. 3 for details on how to interpret the pain bias values. All conditions spent considerably longer fixated upon pain faces than neutral faces in all conditions. Trials in which either AOI was skipped were not included in these estimates. Error bars denote bootstrapped confidence intervals.

APPENDIX A

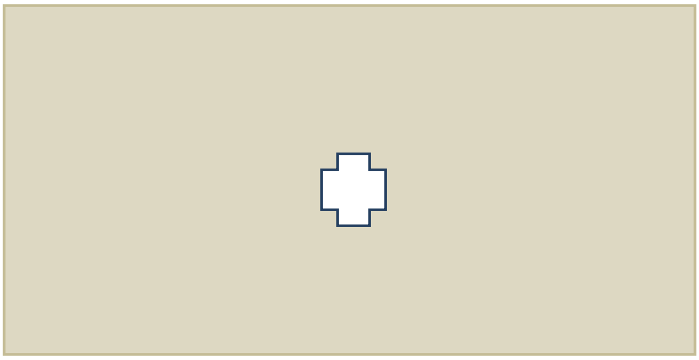
[Paper Based Instructions used in "Imagine-self" Condition (Condition A)]

During the task, you will see a series of slides on the computer screen. Each slide will present two pictures of the same person`s face – as in the example below. The people will change from slide to slide.

The pictures were taken while these people were undertaking a cold-water task - the same task that you have just completed.

Each slide will be presented for 3 seconds.

You can look anywhere on the slides during pictures presentation. Focus on the fixation cross when pictures are not presented. The example of a fixation cross is presented below.



Please read the instructions below carefully. The instructions were designed to ensure that everyone taking part in the experiment approaches the task in the same way.

IMPORTANT

While you are viewing the pictures, try to imagine how **you** yourself would **feel** about what is happening. Concentrate on how **you** would feel while doing the painful cold-water task and how **you** would **be affected by it**. Imagine **your own emotional response** as you would experience the pain.

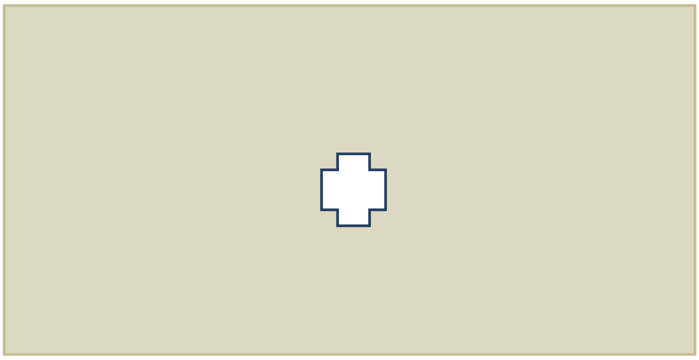
[Paper Based Instructions used in "Imagine-other" Condition (Condition B)]

During the task, you will see a series of slides on the computer screen. Each slide will present two pictures of the same person`s face. The people will change from slide to slide.

The pictures were taken while these people were undertaking a cold-water task - the same task that you have just completed.

Each slide will be presented for 3 seconds.

You can look anywhere on the slides during pictures presentation. Focus on the fixation cross when pictures are not presented. The example of a fixation cross is presented below.



Please read the instructions below carefully. The instructions were designed to ensure that everyone taking part in the experiment approaches the task in the same way.

IMPORTANT

While you are viewing the pictures, try to imagine how **the <u>people you see</u> feel about what is happening.** Concentrate on how **<u>the person</u>** feels while doing the painful cold-water task and how **<u>he/she</u>** is affected by it. Imagine that person`s emotional response as **<u>he/she</u>** experiences the pain.

[Paper Based Instructions used in "Control" Condition (Condition C)]

During the task, you will see a series of slides on the computer screen. Each slide will present two pictures of the same person`s face. The people will change from slide to slide.

The pictures were taken while these people were undertaking a cold-water task - the same task that you have just completed.

You can look anywhere on the slides during pictures presentation. Focus on the fixation cross when pictures are not presented. The example of a fixation cross is presented below.

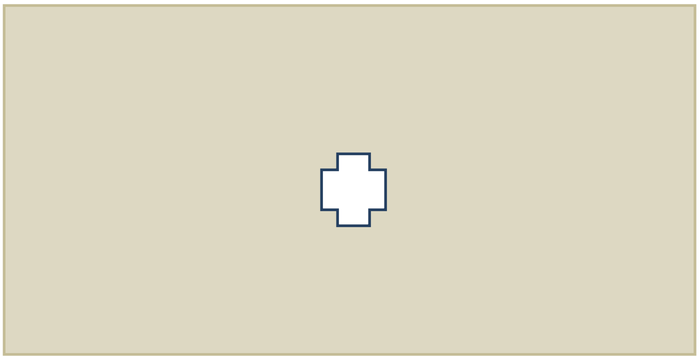


Table 1

Descriptive statistics of sociodemographic variables.

		Experimental Condition													Total (*N =52)*			
		Other (*n =19)*				Self (*n =16)*				Control (*n =17)*								
Variable		***M***	***SD***	***N***	**%**	***M***	***SD***	***N***	**%**	***M***	***SD***	***N***	**%**	***p value***[1]	***M***	***SD***	***N***	**%**
Age		24.04	7.72			19.96	1.3			22.59	8.55			.28	22.45	7.06		
Gender														.58				
	Male			6	31.6			5	31.3			3	17.6				14	26.9
	Female			13	86.4			11	68.8			14	82.4				38	73.1
Education														.63				
	Undergraduate			18	94.7			16	100			16	94.1				50	96.2
	Postgraduate			1	5.3			0	0			1	5.9				2	3.8
Nationality														.27				
	Irish			17	89.5			14	87.5			12	70.6				43	82.7
	Other[2]			2	10.5			2	12.5			5	29.4				9	17.3
Marital Status														.32				
	Single			13	68.4			10	62.5			11	64.7				34	65.4
	Married			0	0			0	0			2	11.8				2	3.8
	In a relationship			6	31.6			6	37.5			4	23.5				16	30.8
Pain Tolerance		142.53	117.08			109.25	110.01			120.41	98.999			.66	125.06	108.03		
IRI PT[3]		20	3.71			18.19	3.73			19.77	4.68			.38	19.37	4.06		

[1]*Note*. The *p* value indicates that there were no significant differences between experimental conditions on the demographic variables
[2]Other nationalities sampled included: 2 German, 1 British, 1 Australian, 1 Russian, 1 Polish,1 Italian, 1 American &1 Indian
[3]Interpersonal Reactivity Index Perspective Taking

Table 2

Probability of First Fixation

Predictor	***B***	***SE***	***z***	***p***	***OR***	***95% CI***	
(Intercept)	0.2023	0.0448	4.5127	*<0.0001*	1.2242	1.1212	1.3367
Self PT Instructions	0.0646	0.1128	0.5726	*0.5669*	1.0667	0.8551	1.3307
Other PT Instructions	-0.0233	0.1063	-0.2190	*0.8266*	0.9770	0.7932	1.2033
Moderate FPE	0.1236	0.1013	1.2206	*0.2222*	1.1316	0.9279	1.3801
High FPE	0.1252	0.1013	1.2359	*0.2165*	1.1334	0.9293	1.3823
Two-Way Interactions							
Self PT Instructions by Moderate FPE	0.0101	0.2552	0.0397	*0.9683*	1.0102	0.6125	1.6660
Self PT Instructions by High FPE	0.1297	0.2399	0.5407	*0.5887*	1.1385	0.7115	1.8218
Other PT Instructions by Moderate FPE	-0.1932	0.2549	-0.7578	*0.4486*	0.8243	0.5001	1.3586
Other PT Instructions by High FPE	0.1177	0.2403	0.4899	*0.6242*	1.1249	0.7024	1.8018

Note. FPE = Facial Pain Expressiveness. The dependent variable was binary, whether the participant fixated on the Pain face first in a trial (Pain first: True; Neutral first: False). Self and Other PT Instructions predictor variables compared the effects of these instructions (+) against the Control condition (-). Moderate FPE and High FPE predictor variables compared the effects of these levels of pain expressiveness (+) against Low FPE. Confidence intervals of the Odds Ratios were estimated using the Wald approximation.

Table 3

Duration of First Fixation

Predictor	***B***	***SE***	***z***	***p***	***OR***	***95% CI***	
(Intercept)	0.1035	0.0293	3.5291	*0.0004*	1.1091	1.0471	1.1747
Self PT Instructions	0.1670	0.0738	2.2612	*0.0237*	1.1817	1.0225	1.3658
Other PT Instructions	0.1065	0.0696	1.5306	*0.1259*	1.1124	0.9706	1.2750
Moderate FPE	0.1013	0.0454	2.2332	*0.0255*	1.1066	1.0125	1.2096
High FPE	0.2165	0.0550	3.9401	*0.0001*	1.2417	1.1149	1.3829
Pain First	-0.1324	0.0038	-34.901	<*0.0001*	0.8760	0.8695	0.8825
Two-Way Interactions							
Self PT Instructions by Moderate FPE	0.0692	0.1142	0.6055	*0.5449*	1.0716	0.8566	1.3405
Self PT Instructions by High FPE	0.1768	0.1077	1.6417	*0.1007*	1.1934	0.9663	1.4738
Other PT Instructions by Moderate FPE	0.0137	0.1383	0.0987	*0.9214*	1.0137	0.7730	1.3295
Other PT Instructions by High FPE	0.0251	0.1304	0.1928	*0.8471*	1.0255	0.7942	1.3241

Note. FPE = Facial Pain Expressiveness. The dependent variable, Pain bias in Duration of First Fixation, was the proportion of first fixation time allocated to the Pain AOI. See Table 2 for descriptions of coding of the Instruction and FPE predictors. The Pain First predictor was estimated as False (i.e., Neutral face was attended to first; -.5) vs True (+.5).

Table 4

Total Gaze Duration

Predictor	***B***	***SE***	***z***	***p***	***OR***	***95% CI***	
(Intercept)	0.7820	0.0793	9.8601	<*0.0001*	2.1859	1.8712	2.5535
Self PT Instructions	0.6149	0.2001	3.0724	*0.0021*	1.8494	1.2494	2.7377
Other PT Instructions	0.7633	0.1890	4.0386	*0.0001*	2.1454	1.4812	3.1074
Moderate FPE	0.1584	0.0469	3.3751	*0.0007*	1.1716	1.0687	1.2845
High FPE	0.2626	0.0628	4.1799	<*0.0001*	1.3003	1.1497	1.4707
Pain First	0.1397	0.0020	70.0387	<*0.0001*	1.1499	1.1454	1.1544
Two-Way Interactions							
Self PT Instructions by Moderate FPE	0.1858	0.1186	1.5672	*0.1171*	1.2042	0.9545	1.5192
Self PT Instructions by High FPE	0.3014	0.1120	2.6902	*0.0071*	1.3518	1.0853	1.6838
Other PT Instructions by Moderate FPE	0.1599	0.1587	1.0075	*0.3137*	1.1734	0.8597	1.6015
Other PT Instructions by High FPE	0.2659	0.1500	1.7721	*0.0764*	1.3046	0.9722	1.7505

Note. FPE = Facial Pain Expressiveness. The dependent variable, Pain bias in Total Gaze Duration, was the proportion of total gaze duration spent in the Pain AOI. See previous tables for details of predictor coding.

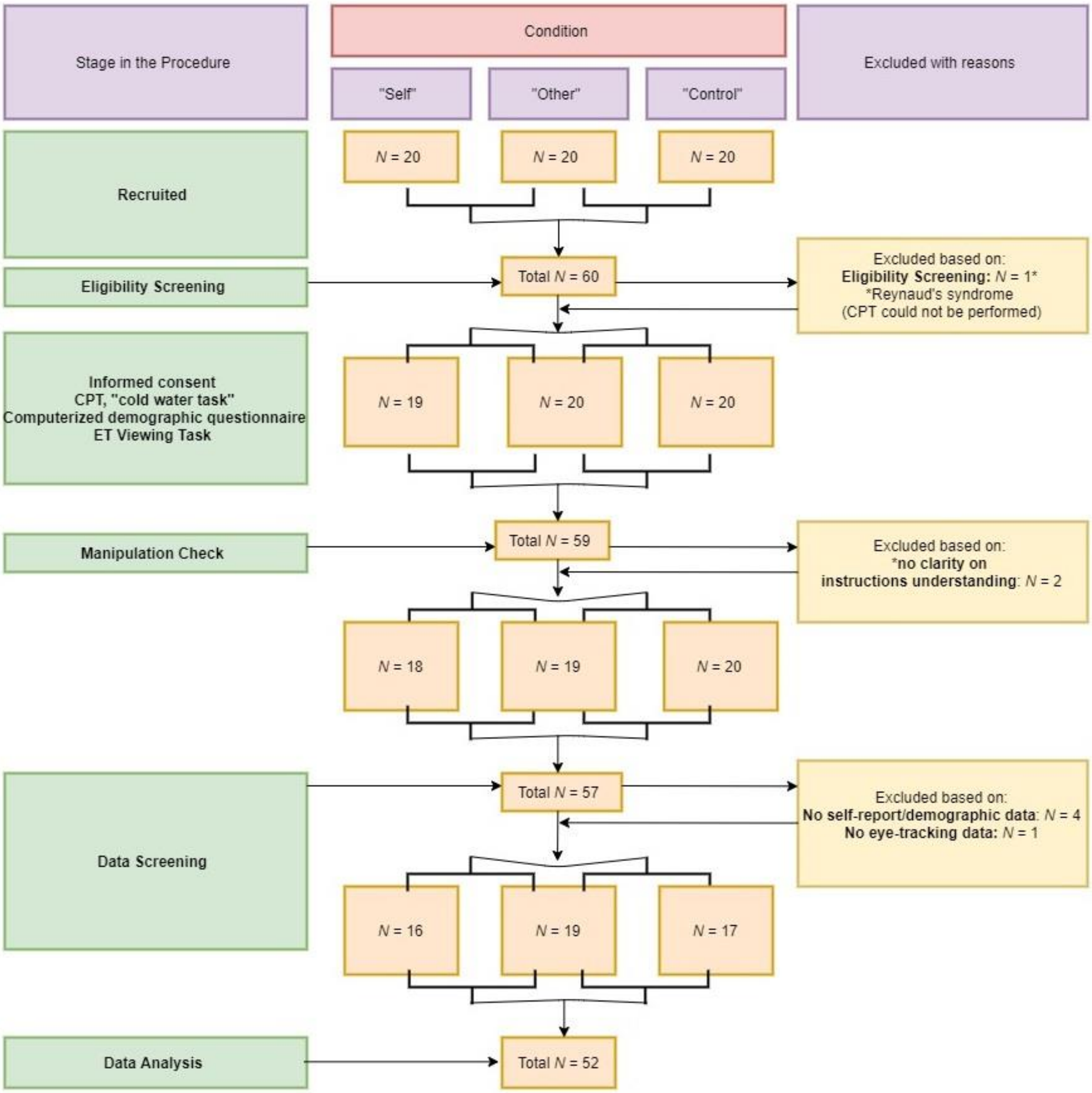


Figure 1. A flowchart diagram of participants exclusion with the decision making rationale.

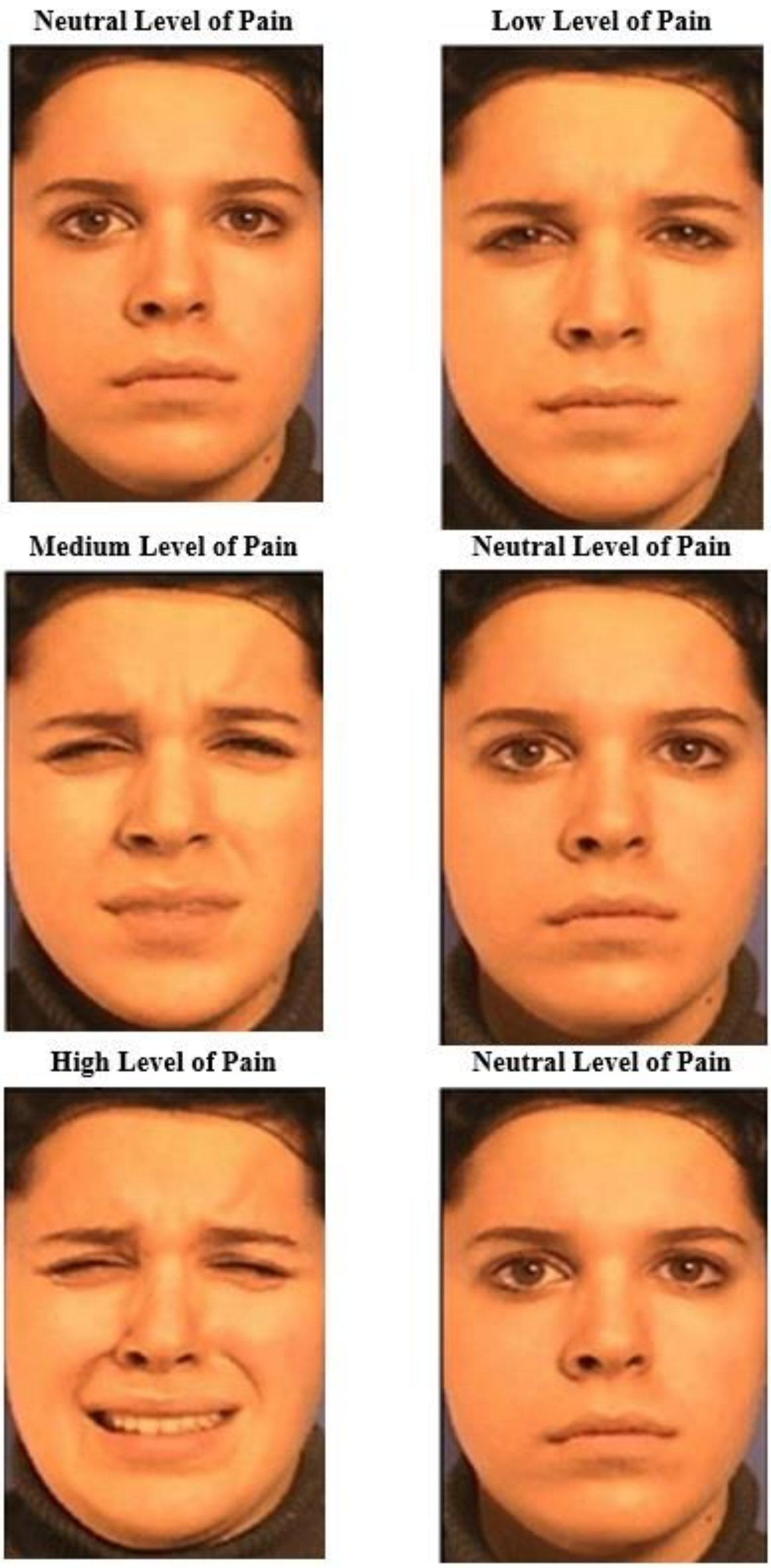


Figure 2. An example of possible neutral-pain face combinations (Left-Right).

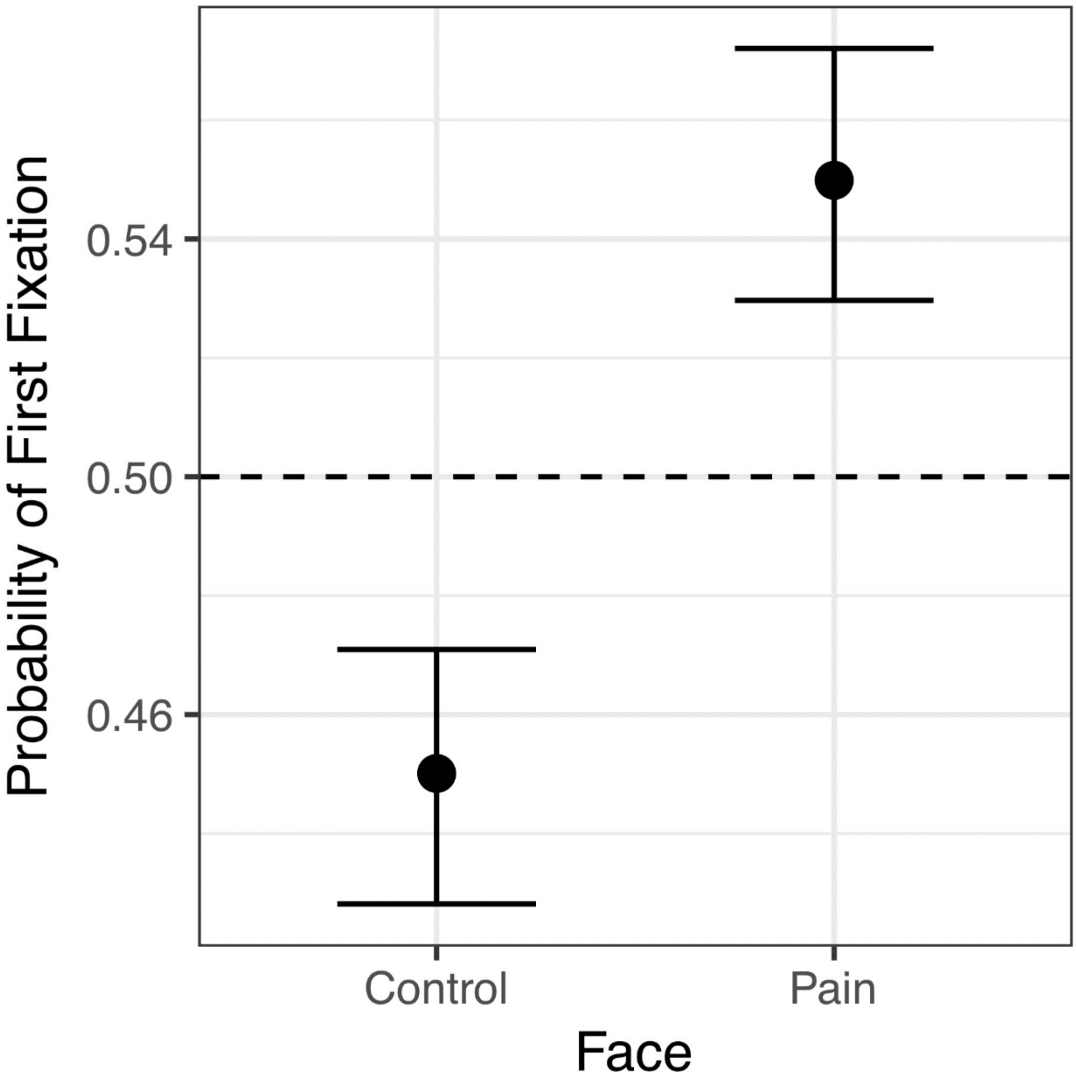


Figure 3. Pain Bias in Probability of First Fixation. Dots denote the mean probability of fixating on the control or pain face first during a trial and error bars denote bootstrapped confidence intervals.

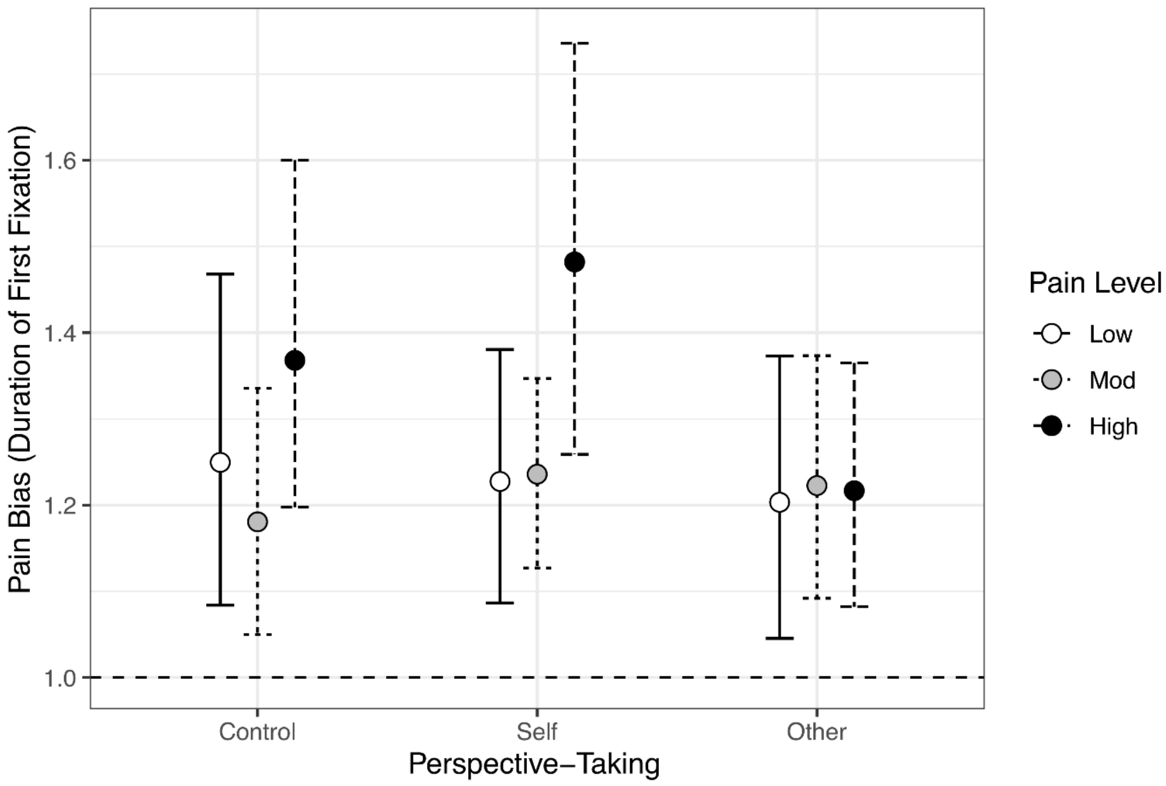


Figure 4. Pain Bias in First Fixation Duration. The plot depicts mean Pain Bias in durations of first fixations across participants for all three levels of Pain Expressiveness in three Instructions conditions. Pain Bias scores were calculated as the within-trial ratio of Pain:Neutral duration of first fixations. Consequently, at 1.2, the Pain:Neutral ratio was 1.2:1 meaning first fixations on Pain faces were were 1.2 times longer than on Neutral faces. When the ratio was 1 (dotted line), first fixations for pain and neutral faces were the same duration. Trials in which either AOI was skipped were not included in these estimates. Error bars denote bootstrapped confidence intervals.

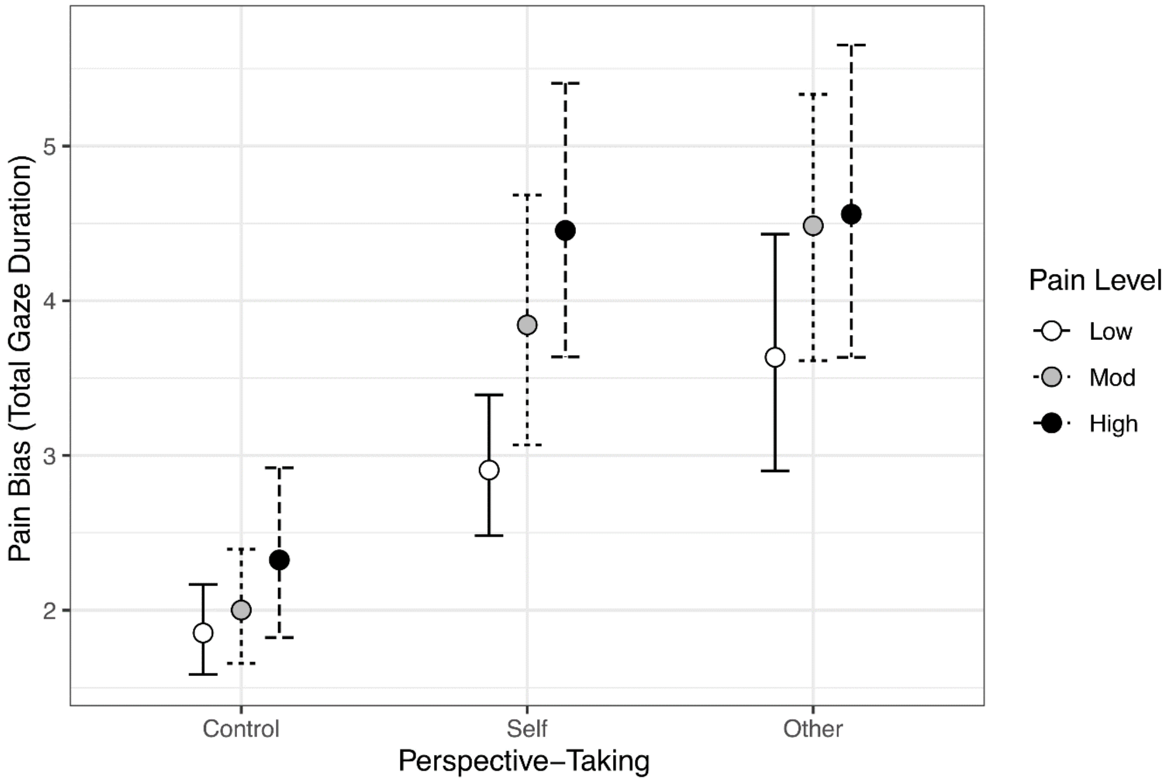


Figure 5. Pain Bias in Total Gaze Duration. The plot depicts mean Pain Bias in Total Gaze Duration across participants for all three levels of Pain Expressiveness in three Instructions conditions. See Fig. 3 for details on how to interpret the pain bias values. All conditions spent considerably longer fixated upon pain faces than neutral faces in all conditions. Trials in which either AOI was skipped were not included in these estimates. Error bars denote bootstrapped confidence intervals.