Individual Differences in Vicarious Pain Perception Linked to Emotional Contagion and Emotional Reactivity

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Abstract

For some people (vicarious pain responders), seeing others in pain is experienced as pain felt on their own body and this has been linked to differences in the neurocognitive mechanisms that support empathy. Given that empathy is not a unitary construct, the aim of this study was to establish which empathic traits are more pronounced in vicarious pain responders.

The Vicarious Pain Questionnaire (VPQ) was used to divide participants into three groups: 1) non-responders (people who report no pain when seeing someone else experiencing physical pain), 2) sensory-localised responders (report sensory qualities and a localised feeling of pain) and 3) affective general responders (report a generalised and emotional feeling of pain). Participants completed a series of questionnaires investigating emotional empathy, cognitive empathic traits such as perspective taking and social skills, prosocial behaviour, and a self-other association task.

Both groups of vicarious pain responders showed significantly greater emotional reactivity (a subscale of Empathy Quotient) and contagion (Emotional Contagion Questionnaire). No differences were recorded in personal distress. There were also no significant differences in pro-social behaviours (Helping Attitudes Scale), individualistic-collectivistic attitudes (The Individualism – Collectivism Interpersonal Assessment Inventory) and a self-other association task.

These results indicate that vicarious pain responses are mainly linked to heightened affective empathy (i.e. emotional reactivity and contagion) suggesting that empathy consists of, at least partially, dissociable components.

1. Introduction

Some people automatically experience and re-create the physical pain of others on their own body and this has been known as vicarious pain responses or synaesthesia for pain (Fitzgibbon, Giummarra, Georgiou-Karistianis, Enticott & Bradshaw, 2010). Pain responses are mainly attributed to shared representations of self and other and supported by overlapping neuronal mechanisms of self-other pain processing (Lamm, Decety & Singer, 2011). Moreover, specific functional and structural neuronal patterns have been distinguished in populations characterised by conscious vicarious pain responses (Grice-Jackson, Banissy, Critchley & Ward, 2017).

In our past work, we developed the vicarious pain questionnaire (VPQ; Grice-Jackson et al., 2017) which separates participants into three categories when they observe the *physical* pain of others: 1) non-responders (report no pain when watching a video with someone else experiencing physical pain), 2) sensory-localised responders (report a stringent localised feeling of pain in the same location as the person in the video) and 3) general-affective responders (report a generalised and emotional feeling of pain). The last two categories have been previously referred to as pain-responders (Derbyshire, Osborn & Brown, 2013). Moreover, the sensory-localised group displays a capacity of mirroring the pain of another on oneself in a fashion similar to the tactile mirroring encountered in mirror-touch synaesthetes (Ward & Banissy, 2015). In the present study, we further investigate how individual differences in vicarious pain perception are linked to both affective and cognitive empathic traits.

A common link has been drawn in the literature between consciously feeling the pain of other and empathy - the capacity to share and understand the emotional states of the others (de Vignemont & Singer, 2006; Lockwood, 2016). Importantly, empathy is not a unitary construct; it implies various components including affective empathy such as emotional contagion or emotional reactivity, cognitive empathy also referred to as Theory of Mind (ToM) or perspective taking, and compassionate empathy or empathic concern which can be associated with the action to help and alleviate other's suffering (Bernhardt & Singer, 2012). Vicarious pain responses seem to have both a strong affective empathic component since they involve the representation of the painful emotional state of the other but also a cognitive/ compassionate component. It is not clear yet to which extent feeling the physical pain of another benefits or impairs social interactions since the affective aspect of empathy is a fundamental process that allows recognising and simulating others' emotional states, but it does not necessarily require a cognitive understanding of their states (Bird & Viding, 2014).

Vicarious pain responses seem to be mainly associated with an emotional reaction towards others' state and previous research indicated that individuals reporting conscious vicarious sensations such as mirror touch synaesthetes (MTS) are more likely to score higher on the emotion reactivity subscale of the Empathy Quotient (EQ) but not on the other subscales (social skills and cognitive empathy) (Banissy & Ward, 2007). In this study, we use both the Emotional Reactivity scale of the EQ and, for the first time, the Emotional Contagion questionnaire to further investigate their association with vicarious pain responses.

There is still a debate regarding the extent to which emotional contagion and reactivity are related to empathy *per se*. For instance, Bird and Viding (2014) highlight that emotional contagion is a precursor of empathy and not an intrinsic component since empathy needs a clear distinction between self and other to occur. Moreover, a complete overlap between self and other representations would produce distress and impair the ability to switch between self and other perspectives, as it is very likely in vicarious responders (Lockwood, 2016). Thus, it is not clear whether strong emotional reactivity, as previously witnessed in vicarious perception, leads to empathic concern and altruistic behaviour or, on the other hand, to personal distress and socially avoidant behaviours. It has been reported that higher levels of affective empathy lead to altruistic/ pro-social behaviour (Batson et al., 1981, Batson et al., 1997) and that pain intensity ratings correlate with higher empathic traits (Lamm, Batson, & Decety, 2007). However, higher levels of personal distress can also be triggered when witnessing other's pain especially if this is accompanied by a negative outcome (Lamm, Batson, & Decety, 2007). As such there is likely to be a fine balance between the extent to which one can tune in to the feelings of others, and also the extent to which one can tune it out (using emotional regulation) to guard against personal distress.

Previous research has shown that that self-other control (the ability to switch focus on information relevant to oneself or relevant to another person) improves performance in social cognitive domains. For instance, increased motor self-other control results in an increased vicarious pain perception and self-reported empathy in typical adults (de Guzman, Bird, Banissy & Catmur, 2015). This is in line with theoretical models of empathy suggesting that interactions between self-other control and vicarious perception may explain individual differences in empathy (e.g. Bird & Viding, 2014), which could perhaps be extended to those studied here. To date, few studies have studied self-other mechanisms in conscious vicarious pain responders (e.g. Derbyshire, Osborn & Brown, 2013). Addressing this gap can enable a greater understanding of the structure of empathy (e.g. Bird & Viding, 2014; Ward & Banissy, 2015), including how individual differences in pain perception affect social cognition (e.g. Happé, Cook & Bird, 2017).

To identify which empathic traits vary in vicarious pain responders, we used a series of questionnaires looking at all these dimensions in the three different groups of people, recruited from the neurotypical population, but classified according to the vicarious pain questionnaire. The groups are the independent variable. The dependent measures were: emotional contagion scale (EC), the helping attitudes scale (HAS), the interpersonal reactivity index (IRI) and the empathy quotient (EQ). These measures were employed to touch on all aspects of empathy from basic emotional contagion to motivational/compassionate empathy, including cognitive and affective aspects of empathy. Notably, most people do not manifest their compassion equally and they tend to favour those who are close to them (e.g. family, partners) and their ingroup, over strangers and out-groups. This also applies to measures relating to vicarious pain (Avenanti, Sirigu & Aglioti, 2010; Hein, Silani, Preuschoff, Batson & Singer, 2010) and suggests a form of control mechanism by which people gate their empathic responses according to the degree to which others are self-related. For instance, family closeness is the strongest followed by closeness towards friends, colleagues and finally strangers (Matsumoto et al., 1997). As such, we tested whether vicarious pain responders show a different pattern (e.g. treating strangers like family) that might give rise to a different empathic response. We investigated the possible differences in degree of social closeness and self-saliency in vicarious pain responders using the individualism-collectivism attitudes questionnaire (Matsumoto et al., 1997) and an abstract self-other association task (Sui, He & Humphreys, 2012). Sui et al (2012) showed how people have faster reaction times when responding to an association made between self and an abstract shape than between another person (friend or stranger) and an abstract shape. These results support the idea that the self is prioritised, and this also seems to vary with cultural differences (Sui, Liu & Han, 2009).

2. Methods

2.1 Participants

A total of 125 participants (mean age=20.89, *SD*=3.34; 104 females) completed the study. Participants were recruited via email invitation or via SONA from Sussex University and Goldsmiths, University of London.

Each participant had previously completed the Vicarious Pain Questionnaire (VPQ) online via Bristol Online Survey (BOS) and were divided into three groups: controls (C), sensory-localised (S/L) and affective-general (A/G) (see section 2.2 for further description). The three groups were derived from a cluster analysis of a much larger dataset of participants who have completed the VPQ (Aged 18-60 yrs, M= 20.42 ± 4.16 SD, 297 Males, 759 Females). Overall there were 68 participants classed as

controls i.e. non-responders (mean age =20.37, S.D.=3.26, 58 females), 37 participants classed as S/L responders (mean age =21.81, S.D.=3.67, 29 females) and 21 participants classed as A/G responders (mean age =21.00, S.D.=2.76, 17 females). The groups did not differ by age ($F(2,124)= 2.241$, $p = 0.111$, $\eta^2=0.035$) or gender ($\chi^2 =0.469$, $p=0.791$). All participants completed the questionnaires: *EC, EQ, IRI, HAS and ICIAI* (controls: N=68 S/L: N=37, A/G: N=21). Due to technical issues, not all participants completed the *self-other association task* (controls: N=55, S/L: N=25, A/G: N=16).
Ethical approval was obtained from the Science and Technology Research Ethics Committee of the University of Sussex.

2.2 Measures

Vicarious Pain Questionnaire (VPQ)

The VPQ is comprised of 16 videos (no audio) of people experiencing physical pain (e.g. falls, sports injuries, injections), each video lasting for approximately 10 seconds (Grice-Jackson, et al., 2017). After each video, participants were questioned about their experience. First, participants were asked if they experienced a bodily sensation of pain while viewing the video (yes/no). If the answer was “yes”’, participants were asked to describe their pain by answering three more questions about their experience: 1) how intense their pain experience was (1-10 Likert scale, 1= very mild pain, 10 = highly intense pain); 2) if and where they localised the pain, answering options were either “localised to the same point as the observed pain in the video”, “localised but not to the same point”, and “a general/non-localisable experience of pain”; 3) to select pain adjectives from a list that best described their vicarious pain experience (10 sensory descriptors such as “tingling”, “burning”, “stinging”, 10 affective descriptors such as “nauseating”, “gruelling”, “aversive” and 3 cognitive-evaluative descriptors “brief”, “rhythmic”, “constant”). All these answers were used to generate the three variables that were entered the two-step cluster analysis (i.e. pain intensity, localised-generalised responses, and sensory – affective responses) which subsequently generated the three groups (for further details see Botan, Fan, Critchley, & Ward, 2018).

Emotion Contagion Scale

The Emotion Contagion Scale (ECS) (Doherty, 1997) is a 15-item self-reported unidimensional scale, with high reliability (Cronbach's $\alpha = .90$) which assesses the susceptibility to others’ emotions. The ECS consists of five basic emotions: love, happiness, sadness, anger, and fear. Each emotion is represented by three items (e.g. *If someone I’m talking with begins to cry, I get teary-eyed* or *Being* *with a happy person picks me up when I'm feeling down)* that are scored on a 5-point Likert scales from 1 - *not at all* to 5 – *always*, with a higher score indicating higher emotional contagion.

Empathy Quotient

A short 15-item version of the Empathy Quotient (EQ) (Muncer, 2006) was used comprising five items for each of the three subscales: Social Skills (SS) (e.g. *I find it had to know what to do in a social situation*) (Cronbach's α = 0.57), Cognitive Empathy (CE) (e.g. *I am good at predicting how someone will feel*) (Cronbach's α = 0.74), and Emotional Reactivity (ER) (e.g. *Seeing people cry does not really affect me*) (Cronbach's α = 0.63). Participants indicate how much they agree with this statement on a 4-point Likert scale, ranging from 1 - *strongly disagree* to 4 - *strongly agree*.

Interpersonal Reactivity Index

The Interpersonal Reactivity Index, or IRI (Davis, 1983), is a multidimensional scale that assesses various components of empathy. There are 28 items which are divided among the four subscales. The subscales are Perspective Taking (PT) (e.g. *I try to look at everybody's side of a disagreement before I make a decision.)*, Fantasy Scale (FS) (e.g. *After seeing a play or movie, I have felt as though I were one of the characters.),* Empathic Concern (EC) (e.g. *I am often quite touched by things that I see happen.),* and Personal Distress (PD) (e.g. *When I see someone who badly needs help in an emergency, I go to pieces*). Each subscale consists of seven items and responses are given on a five-point scale 0 – *does not describe me very well* to 4-*describes me very well*.

Helping Attitudes Scale (HAS)

The Helping Attitude Scale (Nickell, 1998) is a self-report unidimensional measure of pro-social and helping tendencies with good internal consistency (Cronbach's α = 0.869). It comprises 20 items scored on a 5-point Likert scale (1= *strongly disagree* to 5= *strongly agree*). Examples of items are: *Helping others is usually a waste of time; When given the opportunity, I enjoy aiding others who are in need; It feels wonderful to assist others in need*.

The Individualism – Collectivism Interpersonal Assessment Inventory (ICIAI)

The Individualism – Collectivism Interpersonal Assessment Inventory (ICIAI) (Matsumoto et al., 1997) assesses values (Part 1) and behaviours (Part 2) when interacting with others. It takes into account the degree of closeness with the other in four relationship groups: family, friends, colleagues and strangers. We were mainly interested in behaviours and so we only used the second part of the questionnaire. Participants scored from 0 = *never* to 6 = *all the time* how much they engaged in each of the mentioned behaviours towards each of the four relationship groups. The reliability of the questionnaire is high with Cronbach's α = 0.90. The questionnaire contains 19 items and examples are: *Maintain self-control toward them; Share blame for their failures; Sacrifice your possessions for them; Respect them etc.*

Self-other association task

The self-other association task (Sui, He & Humphreys, 2012) requires participants to respond to an association between a geometric shape (triangle, square, or circle) and a label (self, a named best friend, or an unfamiliar person). Participants were first asked to name a best friend and the time-period they had known each other for. Then each of the three geometrical shapes was randomly associated to a label (e.g. *you are a circle, the stated friend is a triangle, and a stranger is a square*). In the matching phase, the participants had to judge if the matches shapes- label pairings were correct. Each trial started with the presentation of a central fixation cross. Subsequently, a pairing of a shape and label (e.g. Δ - *stranger*) was presented for 500ms. The pairing could conform to the initial instruction for each pairing given in the previous stage, or it could be a recombination of a label with a different shape, with the shape–label pairings being generated at random. Immediately after, participants were expected to judge of the association was correct or not. Participants first performed a practice phase containing 20 trials when they were given written feedback (correct or incorrect) followed by three blocks of 120 trials. Thus, there were 60 trials in each condition across all blocks (self-matched, self-nonmatching, familiar-matched, familiar-nonmatching, unfamiliar-matched, and unfamiliar-nonmatching). Reactions times were recorded and analysed as dependent variable in a mixed model ANOVA.

Procedure

The questionnaires were administered via Bristol Online Survey (BOS), an online software for collecting questionnaire data. The self-other association task was run via Inquisit (www.millisecond.com), an online survey for collecting both questionnaire and tasks data.
Participants filled in the questionnaires and, subsequently, they were re-directed to the task. The study took approximately 40 minutes (30 minutes for questionnaires and 10 minutes for the task). All questionnaires were completed in the same order (as outlined above).

Statistical analyses

Analyses of variance (ANOVAs) were used to established differences between groups on the various scales. Variables were treated as continuous and the great majority of them were normally distributed as shown by Shapiro-Wilk tests and histograms. Normality assumptions were violated only in the following cases: controls (IRI-EC (p=0.01) and ICIAI family (p=0.01) and colleagues (p=0.04); S/L (EQ-C (p=0.02), IRI-EC (p=0.01)). For these cases, Kruskal-Wallis non-parametric tests were run, re-confirming the results (see supplementary results S1). All analyses were run in SPSS *separately for each measure* and test-wise Bonferroni confidence interval adjustment was used for comparisons of main effects. Both Games-Howell and Hochberg's GT2 post-hoc tests for different sample sizes were run (Field, 2005). Effect sizes (Cohen's d) were also calculated and reported in supplementary results S2.

3. Results

There were significant group differences on emotional contagion (F(2,122) = 5.281, p=0.006, η^2=0.08), both sensory-localised and affective-general groups scored higher than controls (S/L: p= 0.02, A/G: p=0.03) but did not differing from each other (p=0.915).

On the Empathy Quotient, there was a significant group difference on the emotional reactivity subscale of the EQ (F(2,122) = 5.247, p= 0.007, , η^2=0.08), with both sensory-localised and affective-general groups scored higher than controls (S/L: p= 0.02, A/G: p=0.05) but not different from each other (p=0.99). None of the other subscales of the EQ showed differences between groups: Cognitive Empathy (F (2,122) = 2.297, p= 0.105, η^2=0.031) and Social Skills (F(2,122) = 0.370, p= 0.695, η^2=0.006).

The results of the questionnaire measures are summarised in Figure 1.

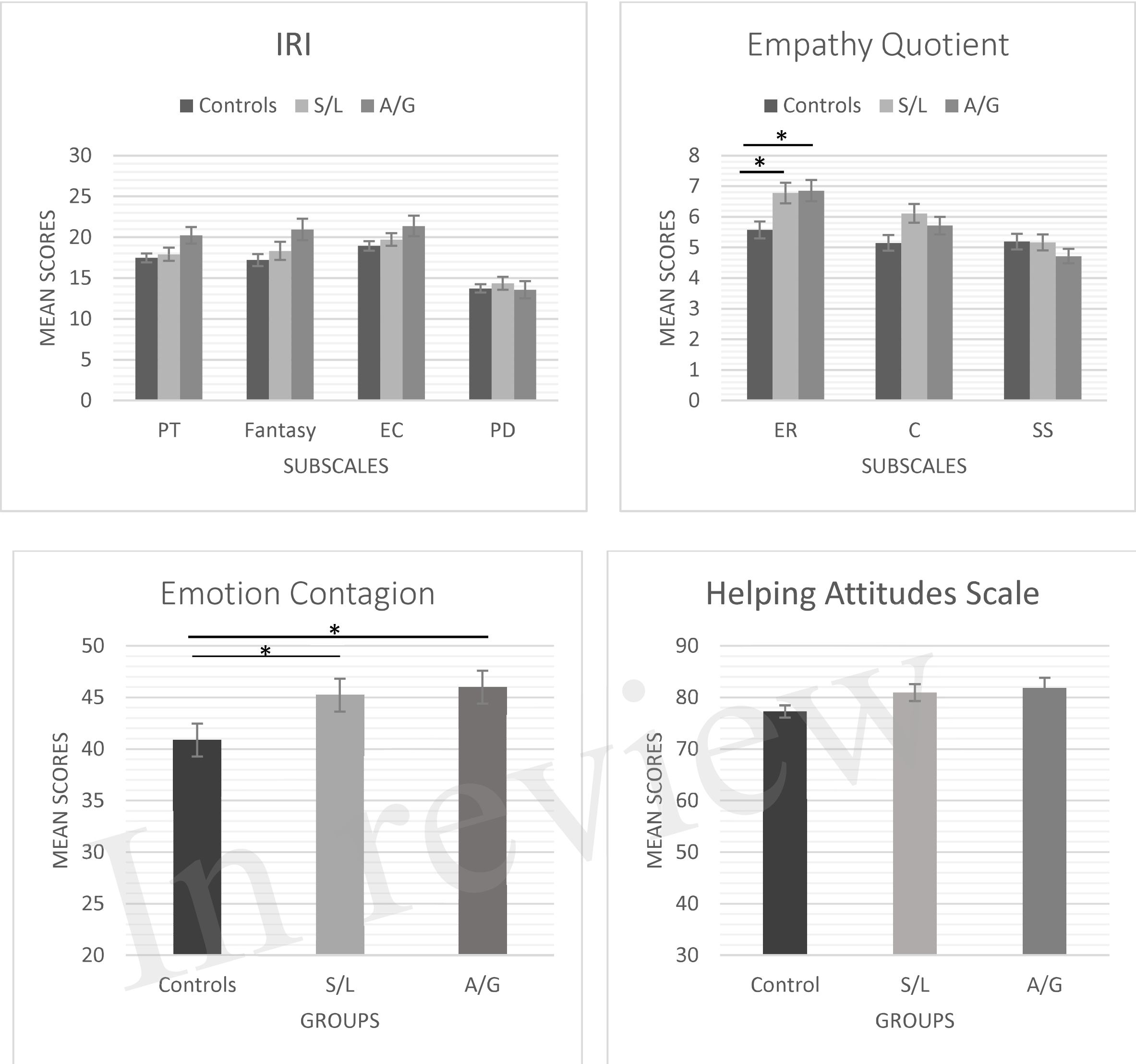

Figure 1 EC, EQ, IRI and HAS scores. S/L = sensory-localised, A/G = affective-general. Both S/L and A/G scored higher on emotional contagion and emotional reactivity (ER) than controls but not on cognitive empathy (CE) or social skills (SS) subscales. No significant differences were found on IRI and HAS. Error bars indicate +/- 1SE.

IRI scores did not show any significant differences on Personal Distress ($F(2,122) = 0.296$, $p= 0.744$, $\eta^2=0.005$) or in empathic concern ($F(2,122) = 0.296$, $p= 0.141$, $\eta^2=0.032$) but there was a trend towards increased scores in vicarious perceivers for perspective taking ($F(2,122) = 2.930$, $p= 0.057$, $\eta^2=0.046$) and fantasy ($F(2,122) = 2.981$, $p= 0.054$, $\eta^2=0.047$) subscales.

The Helping Attitudes Scale (HAS) revealed no significant differences between groups ($F(2,122) = 2.576$, $p= 0.08$, $\eta^2=0.041$).

The Individualism-Collectivism Interpersonal Assessment (ICIAI) was analysed as a 3X3 mixed ANOVA contrasting group (control, S/L, A/G) and closeness (family, friend, stranger). There was a main effect of closeness ($F(3,122)=246.405$, $p<0.001$, $\eta^2=0.669$) but there was no main effect of group ($F(2,122)=0.619$, $p=0.941$ $\eta^2=0.001$) or interaction ($F(6,122)=0.536$, $p = 0.949$, $\eta^2=0.003$). At a behavioural level, the self-other association task was also analysed as a 3x3 mixed ANOVA contrasting group (control, S/L, A/G) and closeness (self, friend, stranger) on response times to correctly endorse matching pairs (see Sui, He & Humphreys, 2012). There was a significant effect of closeness ($F(2,94)=29.818$, $p<0.001$, $\eta^2=0.241$) but no main effect of group ($F(2,94)=0.600$, $p = 0.551$, $\eta^2=0.013$) and no interaction ($F(4,1.940)=0.134$, $p = 0.781$, $\eta^2=0.009$). Correlations between the questionnaire empathic measures and task RTs were run on the entire sample but there were no significant results (see figure 2).

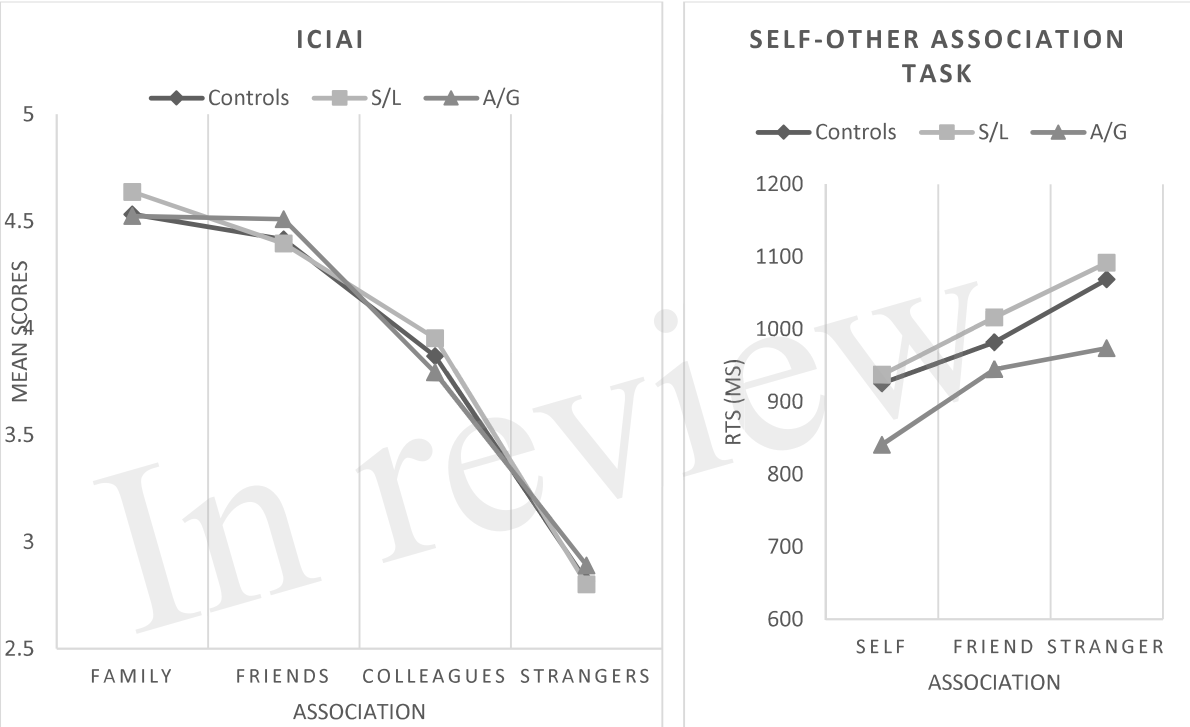

Figure 2 ICIAI and self-other association task results. S/L = sensory-localised, A/G = general affective. The effects of closeness appear both in subjective scores and in task reaction times but not as an effect of group. All groups show a similar trend in RTs to the self-other association.

All together, these results indicate that vicarious pain perceivers have heightened empathic traits such as emotional contagion and reactivity, but they do not differ on other dimensions of empathy (e.g. cognitive empathy) or related skills (e.g. pro-social behavioural, self-other association).

4. Discussion

The capacity to co-represent the feelings of other people has a central role in most theoretical accounts of empathy (de Vignemont & Singer, 2006; Lockwood, 2016). However, the mechanism by which this occurs remains under debate as does its relationship to social behaviour. For instance, whilst empathy may underpin acts of compassion (Singer & Klimecki, 2014) it has also been claimed that too much empathy can be detrimental (Bloom, 2017). In the present study, we took advantage of a recently reported individual difference in the neurotypical population; namely, the extent to which people report consciously feeling pain when observing other people in pain. Some people report feeling the pain of others either localised on the corresponding part of their own body (Sensory-Localised responders, S/L) or a non-localised, more general body feeling (Affective-General responders, A/G). However, the majority of people report no conscious feelings of pain: they either have an implicit simulation or possibly do not simulate the pain of others. In this study we assessed for the first time how these individual differences in vicarious pain are linked to differences in affective empathy, social cognition, and social behaviours. The two vicarious pain responder groups differed from control groups on several measures, although they never differed from each other (previous research has shown that the two groups differ in other respects (e.g. Grice-Jackson, et al., 2017; Botan et al., 2018). As such we refer to the results from S/L and A/G collectively as 'vicarious pain responders'.

Vicarious pain responders report a greater perception of socially elicited emotional states, namely measures of Emotion Contagion, and Emotional Reactivity on the EQ. This suggests that vicarious pain perception is probably just one trait of a much broader phenotype in conscious vicarious pain responders (including emotion contagion as well as the defining symptom of 'pain contagion'). They did not, however, report being concerned or distressed by this (as shown by the Personal Distress scale of IRI). In the wider literature, symptoms such as emotional contagion are regarded as developmental precursors of empathy, which are diminished as emotional regulation mechanisms mature (Thompson, 1991; Eisenberg, 2000). People with vicarious pain appear to have retained a high capacity for emotional contagion but without reporting a concomitant problem in regulating or coping with these symptoms. Osborn and Derbyshire (2010) also reported that, in vicarious pain responders, there was no correlation between vicarious pain intensity and personal Distress. The fact that vicarious pain perceivers do not have higher levels of Personal Distress may be due to habituation to pain which sometimes is noticed in response to frequent exposure to pain (Bingel et al., 2007) or to the fact that they developed a response mechanism towards occurrence of pain. Thus, a testable prediction is that these populations would have higher emotional regulation which would be recorded in both questionnaires and physiological measures such as heart-rate variability (Appelhans & Luecken, 2006) and would shed more light on bodily and emotional processing in vicarious pain responders.

Moreover, these differences in emotional responsivity do not translate strongly into higher social skills (on the EQ), helping behaviour (on the HAS), or aspects of empathy that require taking on board someone else's viewpoint (Perspective Taking on IRI; Cognitive Empathy on the EQ). Nor do they manifest themselves in terms of a greater tendency to treat other people as self-related (on

Individualism-Collectivism measure, or the Self-Other association task) indicating that the heightened emotional contagion and reactivity does not strongly affect social cognition and inter-personal relations.

Notably, vicarious pain responders have increased grey matter density in primary somatosensory cortices and anterior insula (Grice-Jackson et al., 2017). The fact that they scored higher on emotional contagion and reactivity is in line with the idea that affective empathy may be linked to cortical representation in the somatosensory cortex, however other regions such as the anterior insula may also be involved (Singer, Critchley & Preuschoff, 2009). Differences in the rTPJ have also been found in vicarious pain responders (Grice-Jackson et al., 2017), both groups having lower grey matter in this region mainly involved in perspective taking, self-other control but also selective visual and task attention (Halligan et al, 2003; Santiesteban et al, 2012). Previous findings have indicated that vicarious pain responders are better at perspective taking as recorded by an avatar PT task (Derbyshire, et al., 2013) but we did not find any differences in our groups apart from a trend in the A/G group on the PT subscale of IRI. These results reflect the different nature of the measures employed. It may be that the avatar PT task requires mainly attention processes that lack social saliency (Santiesteban et al., 2014) but also that the role of the rTPJ is still ambiguous when differentiating between attentional and socio-cognitive processes (Cook, 2014). Further studies combining behavioural and neuroscientific measures in these groups are needed to establish their PT ability and the role of rTPJ. We propose that the mechanisms of emotional empathy and cognitive empathy can be dissociable as previously indicated by neuroanatomical evidence. Both affective and cognitive empathy have been linked to shared representations in the sensorimotor cortices (Avenanti, Bueti, Galati & Aglioti, 2005). However, affective empathy (such as responses to other's physical pain) has been shown to recruit an extended system which includes the anterior insula, the anterior cingulate cortex, and somatosensory cortices (Lamm et al., 2011).

Despite having shared representations of pain and enhanced affective empathy, vicarious pain responders did not report enhanced social skills and neither pro-social attitudes. It seems like these behaviours are neither impaired nor stimulated by strong emotional responses as previously vehiculated by Bloom (2017) (N.B. we only recorded general, trait attitudes in this study and not immediate responses to painful stimulation). Surprisingly this ability seems to neither benefit nor impair social skills suggesting that the mechanisms for these different empathic qualities could be segregated and function independently, but the mechanism is not yet fully understood.

There were no differences in self-other associations between vicarious pain responders and controls. In both the subjective (ICIAI questionnaire) and objective (self-other association task) measures, we would have expected a linear trend showing that vicarious pain responders treated unknown others as close ones or as self. The results did not confirm this hypothesis. The ICIAI has a strong cultural component whilst the self-other association task requires an abstract association and recorded reaction times to congruent or incongruent association between a geometrical shape and a label. The task mainly determines changes in perceptual saliency by employing various self- other associations and the use of self-associated labels. Importantly this type of task does not require participants to engage in online control of self-other representations. That is to say that participants do not have to co-represent themselves and others in the same trial because they are cued towards self or other, and thus it is unlikely that self or other are represented at the same time (i.e. only the self or other is represented, but not both). Prior work suggests that the online control of co-activated self-other representations is linked to empathy and associated brain networks including the rTPJ (e.g. Nobusako et al., 2017; Santiesteban et al., 2012; Santiesteban et al., 2015; Sowden et al., 2015), but the ability to attribute mental states to the self or others does not tend to recruit this same brain network (e.g. Lombardo et al., 2010; Sui, Rotshtein & Humphreys, 2013; Sui, Liu, Mevorach & Humphreys, 2013). Given that individuals with conscious vicarious pain perception have been shown to differ in their neural profile within the rTPJ (Grice-Jackson et al., 2017) it perhaps more likely that they will differ on tasks that involve the online control of co-activated self-other representations, than tasks that tap into the ability to attribute states to the self or others via cues like the one used in the current investigation.

Overall, our results indicate that that vicarious pain perception are mainly linked to heightened affective empathy (i.e. emotional reactivity and contagion) but not to cognitive or compassionate empathy including social skills and pro-social behaviours and neither personal distress. These results stress the importance of the somatic nature of conscious vicarious pain and suggest that the two empathic components can be dissociable.

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Supplementary Results

S1. Non-parametric tests results.

Kruskal-Wallis H test for measures that were not normally distributed re-confirmed the parametric test results regarding differences between groups: EQ-C ($\chi^2 = 5.061$, $p = 0.080$), IRI-EC ($\chi^2 = 4.698$, $p = 0.095$), ICIAI family ($\chi^2 = 0.710$, $p = 0.701$) and colleagues ($\chi^2 = 1.284$, $p = 0.526$).

S2. Effect sizes

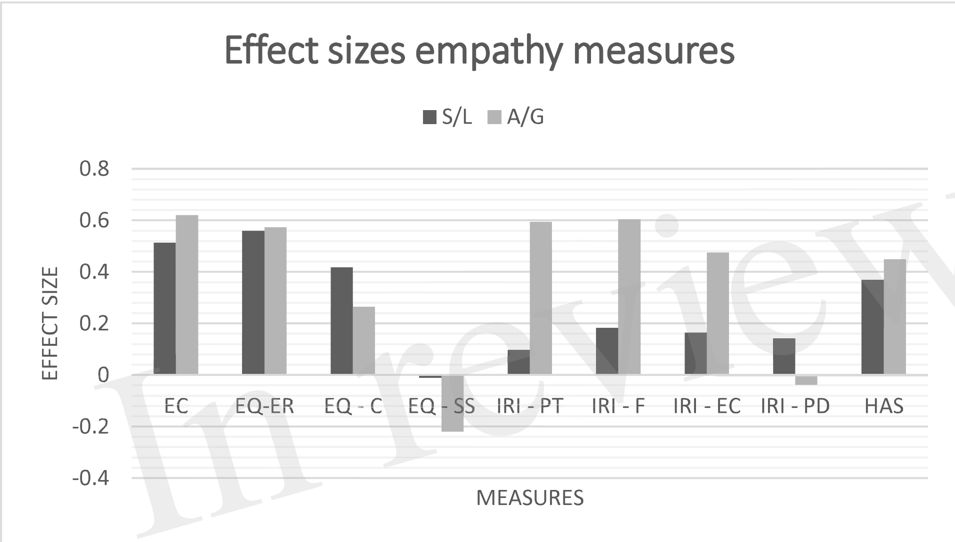

Figure 3 Effect sizes for EC, EQ subscales, IRI subscales and HAS for S/L and A/G when compared to controls. Medium effect sizes (d>0.5) were observed on EC and EQ-ER for both S/L and A/G and on IRI-PT and IRI-F only for A/G. All the other effect sizes were small.

Figure 1.JPEG

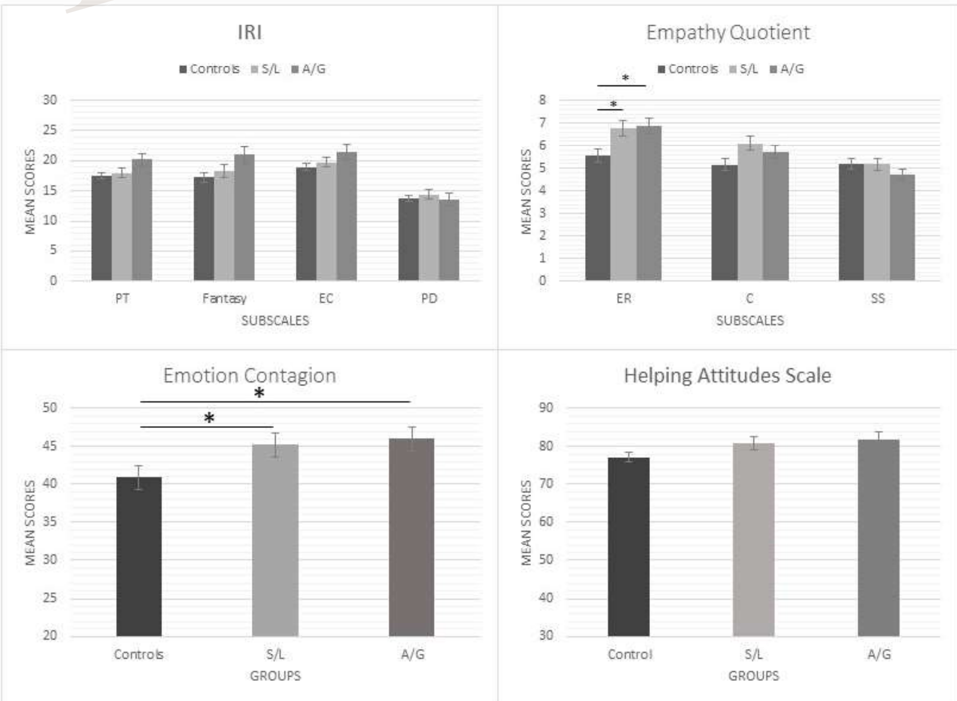

Figure 1 EC, EQ, IRI and HAS scores. S/L = sensory-localised, A/G = affective-general. Both S/L and A/G scored higher on emotional contagion and emotional reactivity (ER) than controls but not on cognitive empathy (CE) or social skills (SS) subscales. No significant differences were found on IRI and HAS. Error bars indicate +/- 1SE.

Figure 2.JPEG

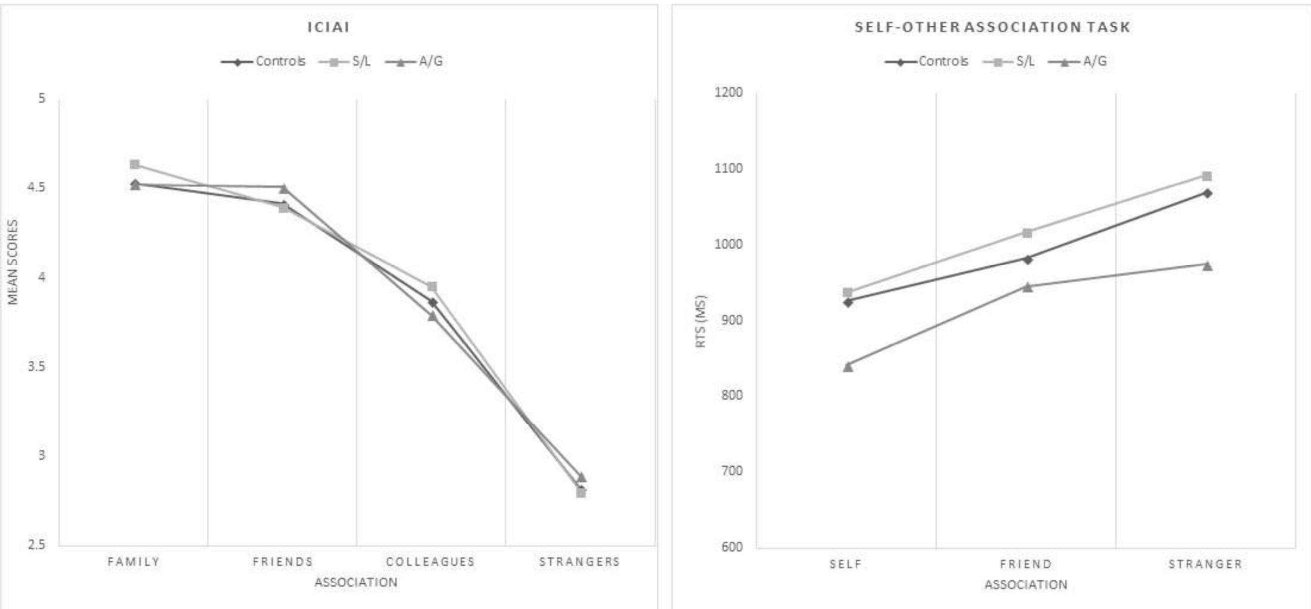

Figure 2 ICIAI and self-other association task results. S/L = sensory-localised, A/G = general affective. The effects of closeness appear both in subjective scores and in task reaction times but not as an effect of group. All groups show a similar trend in RTs to the self-other association.