NeuroImage 114 (2015) 371–378

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg

Responsibility modulates pain-matrix activation elicited by the expressions of others in pain

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ARTICLE INFO

Article history:
Received 9 December 2014
Accepted 13 March 2015
Available online 20 March 2015

Keywords:
Empathy
fMRI
Pain
Responsibility

ABSTRACT

Here we examine whether brain responses to dynamic facial expressions of pain are influenced by our responsibility for the observed pain. Participants played a flanker task with a confederate. Whenever either erred, the confederate was seen to receive a noxious shock. Using functional magnetic resonance imaging, we found that regions of the functionally localized pain-matrix of the participants (the anterior insula in particular) were activated most strongly when seeing the confederate receive a noxious shock when only the participant had erred (and hence had full responsibility). When both or only the confederate had erred (i.e. participant's shared or no responsibility), significantly weaker vicarious pain-matrix activations were measured.

Introduction

Perceiving the facial expressions of pain in others has important social functions. In particular, perceiving the pain of others motivates and regulates helping behavior (Craig et al., 2001; Williams, 2002). Over the past decade, our understanding of the neural basis of this perception has been refined by a number of experiments that have exposed participants to the facial expressions of pain of others. After reviewing this evidence, we will show that a common feature of these experiments has been to show expressions of pain that were not caused by the participant him or herself. Accordingly, we will argue that an important aspect of the neural basis of pain perception has been left unexplored: how this neural activation is modulated by the degree to which the observer caused the witnessed pain.

There is a long tradition of studying the neural basis of the visual processing of facial expressions in general. The observation of facial expression triggers activity in early visual cortex, in the human occipital face area (OFA) and in the middle temporal gyrus along the superior temporal sulcus (STS) (see Said et al., 2011 for a review). Additionally, facial expressions activate the frontal operculum, supplementary motor area (SMA) and somatosensory cortices that are also activated when participant produce facial expressions. The vicarious activation to viewing others' facial expressions of these sensorimotor brain regions has thus been interpreted as representing an internal simulation of the sensorimotor neural activity associated with producing the observed facial expressions (Bastiaansen et al., 2009; Said et al., 2011; van der Gaag et al., 2007). When witnessing facial expressions of pain, participants have been shown to additionally activate regions of the anterior insula (AI), anterior cingulate cortex (ACC) and the amygdala (Botvinick et al., 2005; Saarela et al., 2007; Simon et al., 2006). Because the AI, ACC and amygdala are part of the pain-matrix — the set of brain regions that are activated when the participants themselves are exposed to noxious stimuli on their body (Garcia-Larrea and Peyron, 2013; Melzack and Wall, 1965; Mouraux et al., 2011) — and because their level of activation during the experience of pain correlates with the unpleasantness of experienced pain (Rainville, 2002), many interpret their vicarious activation while witnessing the pain of others as the neural correlate of empathy — feeling vicariously what we see someone else to experience (Corradi-Dell'Acqua et al., 2011; Jackson et al., 2006; Koban et al., 2013; Lamm et al., 2011; Singer et al., 2004). That AI, ACC and amygdala are also vicariously activated when pain is perceived through non-facial cues (Corradi-Dell'Acqua et al., 2011; Jackson et al., 2006; Koban et al., 2013; Lamm et al., 2011; Meffert et al., 2013; Singer et al., 2004) supports the notion that these activations have less to do with the facial expressions as a motor act and more with pain as a perceived emotion. That their activation is stronger in more empathic individuals (Singer et al., 2004) and weaker in psychopaths (Meffert et al., 2013) further supports their role in empathy. Interestingly, the magnitude of vicarious activations in the AI also predicts helping behavior (Hein et al., 2010) providing evidence that vicarious activations could have behavioral significance by motivating the witness to help another. It should be noted, however, that experiencing negative emotions other than pain also activates regions such as the

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http://dx.doi.org/10.1016/j.neuroimage.2015.03.034

amygdala, AI and ACC. For instance the experience of disgust recruits all of these regions (Wicker et al., 2003), and so does the emotion of guilt (Jankowski and Takahashi, 2014). Accordingly, vicarious activations in these regions cannot unambiguously be interpreted as representing vicarious pain, but could involve a mixture of emotions, such as concern or distress. Need for caution in interpreting activity in these regions as