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Review

Shared pain: From empathy to synaesthesia

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A B S T R A C T

This paper reviews the current literature on "empathy for pain", the ability to understand pain observed in another person, in the context of a newly documented form of pain empathy "synaesthesia for pain". In synaesthesia for pain a person not only empathises with another's pain but experiences the observed or imagined pain as if it was their own. Neural mechanisms potentially involved in synaesthesia for pain include "mirror systems": neural systems active both when observing an action, or experiencing an emotion or sensation and when executing the same action, or personally experiencing the same emotion or sensation. For example, we may know that someone is in pain in part because observation activates similar neural networks as if we were experiencing that pain ourselves. We propose that synaesthesia for pain may be the result of painful and/or traumatic experiences causing disinhibition in the mirror system underlying empathy for pain. We will discuss this theory in the context of a documented group of amputees who experience synaesthesia for pain in phantom limbs.

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1. Introduction

The International Association for the Study of Pain (1994) defines pain as an unpleasant sensory and emotional experience caused by real or possible tissue damage. The neural processes involved in the experience of 'empathy for pain', the understanding of pain in another (other-pain), are not well understood. This review presents a new field of enquiry: synaesthesia for pain (Giummarra and Bradshaw, 2008). Synaesthesia occurs when stimulation in one sensory domain causes a sensation in another

Abbreviations: ACC, anterior cingulate cortex; AI, anterior insula; ASD, autistic spectrum disorders; CIP, congenital insensitivity to pain; EEG, electroencephalography; fMRI, functional magnetic resonance imaging; IC, insula; MEG, magnetoencephalography; MNs, mirror neurons; MNS, mirror neuron system; ROI, region of interest; S1, primary somatosensory cortex; S2, secondary somatosensory cortex; SEPs, somatosensory evoked potentials; TMS, transcranial magnetic stimulation.

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domain (for a review, see Rich and Mattingley, 2002). For example, in its most common form, digits, letters or words evoke the perception of a colour (Simner et al., 2006). In the case of synaesthesia for pain, people describe that the empathic response of observing pain in another causes an actual sensation of pain in oneself (Giummarra and Bradshaw, 2008). We expect that synaesthesia for pain and empathy for pain share overlapping neural correlates; however, in synaesthesia for pain these networks may be activated above the level required for conscious perception.

Empathy is the ability to understand the emotional state of others in the context of the self (de Vignemont and Singer, 2006; Decety and Jackson, 2004). This ability allows us to understand and predict the behaviours or emotions of other people (Singer, 2006; Singer et al., 2004) and to respond appropriately in our actions, thoughts and desires towards them (Batson, 1990). Empathy may occur via simulation of another person's state. Neurobiological models of this simulation hold that observing another person's state activates overlapping cortical areas, "mirror systems", as if the observer was in that same state themselves (Decety and Jackson, 2004; Gallese, 2003; Preston and de Waal, 2002). Initial evidence suggesting that empathy for pain may be mediated by mirror systems emerged with the finding that neurons in the anterior cingulate cortex (ACC) fire in response to both pain in the self and the observation of pain in another person (Hutchison et al., 1999). Consequently, research has demonstrated that areas within the "pain matrix" (regions of the brain involved in processing pain to the self; self-pain) become active during the experience of empathy for pain in normal populations (Jackson et al., 2006b).

In this paper, we review current literature on empathy for pain. We suggest that synaesthesia for pain is an abnormal form of empathy for pain, and discuss potential mechanisms that may underlie the experience of another's pain. Specifically, we propose that dysfunctional mirror systems may alter empathic processes by causing the mapping of motor/emotion/perceptual states in a way that exceeds the threshold for conscious experience of those states. Because more cases of pain synaesthesia have been reported in phantom pain patients than any other patient group (see Giummarra and Bradshaw, 2008) we discuss this proposal within the context of amputees suffering from phantom pain; the experience of pain in an absent extremity (Flor, 2002; Flor et al., 2006).

2. Processing pain in the self vs. processing pain in another

While there has been much debate on the neural processes underlying pain perception (see Treede et al., 1999), the way pain is experienced by the individual is influenced by a combination of sensory-discriminative, affective-motivational and cognitive-evaluative factors (Melzack and Casey, 1968; Ploghaus et al., 1999; Price, 2000; Treede et al., 1999). Whereas the sensory-discriminative component of pain allows one to determine where and how intense the pain is in one's body, the affective-motivational component allows one to determine how unpleasant the pain is and to react with a fight or flight response if appropriate (Avenanti and Aglioti, 2006). The cognitive-evaluative component of pain involves higher order processing and its influence over the experience of pain (Melzack and Casey, 1968). For example, attention, expectation and reappraisal may influence how a painful experience is interpreted (Wiech et al., 2008).

Areas of the brain involved in these processes underlying pain perception are centrally located in the pain matrix (Melzack and Casey, 1968). The pain matrix includes the thalamus, contralateral primary somatosensory cortex (S1), secondary somatosensory cortices (S2), insula (IC), ACC, and prefrontal areas (Apkarian et al., 2005; Peyron et al., 2000; Treede et al., 1999). While some of these individual regions (e.g. the ACC and the anterior insula, AI) are involved in processing the affective component of pain (Peyron et al., 2000; Rainville, 2002), others regions (e.g. the somatosensory cortices) may be more involved in processing the sensory component of pain (Bushnell et al., 1999; Hofbauer et al., 2001; Ingvar, 1999; Porro et al., 1998). Activation of the pain matrix is not exclusive to the experience of pain in response to noxious stimuli in the self, but it is also activated in phantom pain (Willoch et al., 2000), social rejection (Eisenberger et al., 2003) and empathy for pain (for a review, see Jackson et al., 2006b).

While empathy for pain is an attractive model for investigating social cognition and mirror systems (Avenanti and Aglioti, 2006; Bufalari et al., 2007) several questions surrounding the experience of empathy for pain remain: does understanding another person's pain require just the affective component or is the sensory component also critical? As discussed in Section 5, most studies investigating activation of the pain matrix in empathy for pain have found overwhelming affective but not sensory activation; however, new techniques have recently found sensory activation. If the experience of empathy for pain does indeed require a sensory component, why do we not always experience the pain we observe in another person?

3. Synaesthesia for touch and pain

"Synaesthesia for touch" (also known as mirror-touch) occurs when the observation of touch causes a tactile sensation in the observer (see Banissy and Ward, 2007; Blakemore et al., 2005; Serino et al., 2008). A mirror system for touch has been identified in somatosensory neural structures (Blakemore et al., 2005; Keysers et al., 2004). While this neural overlapping does not typically result in the experience of touch through observation alone, this is not the case for 'touch synaesthetes'. Similarly, for 'pain synaesthetes', empathy for another's pain results in the subjective sensation of pain. At present, there are few published cases of pain synaesthesia. We will review current studies of synaesthesia for touch and pain and briefly describe potential mechanisms that may underlie these sensory synaesthetic phenomena. First, however, we will qualify our use of the term "synaesthesia" to describe synaesthesia for pain as an empathic process.

While synaesthesia for pain is typically acquired later in life, most reports of synaesthesia are developmental. Ro et al. (2007) suggest that acquired forms of synaesthesia differ from developmental forms of synaesthesia in many crucial ways. First, acquired synaesthetic sensations are often less specific than the sensations experienced in developmental synaesthesia. For example, feeling a tingling sensation in response to sound in acquired synaesthesia (Ro et al., 2007), compared to experiencing specific tastes, such as bread soaked in tomato soup, in response to words in developmental synaesthesia (Ward and Simner, 2003). Second, developmental and acquired forms of synaesthesia tend to involve different sensory modalities. For example, developmental synaesthesia involves the blending of unrelated sensory information, e.g. grapheme-colour (Simner et al., 2006), while reports of acquired synaesthesia include converging representations from different modalities, e.g. sound–touch synaesthesia (Ro et al., 2007), touch–vision (Armel and Ramachandran, 1999) and synaesthesia for pain (Giummarra and Bradshaw, 2008). We feel synaesthesia for pain is a true acquired synaesthesia as vision and pain demonstrate a clear link, as in synaesthesia for touch (e.g. Blakemore et al., 2005).

In the first study of synaesthesia for touch, Blakemore et al. (2005) used functional magnetic resonance imaging (fMRI) to map brain activity underlying both non-synaesthetic and synaesthetic perception of touch. Observing touch activated the tactile mirror system in both synaesthetes and non-synaesthetes, although activation was greater in the case of synaesthesia. This finding suggests that whereas the tactile mirror system is typically activated