Available online at www.sciencedirect.com
ScienceDirect
Current Opinion in Neurobiology

I feel how you feel but not always: the empathic brain and its modulation

Grit Hein and Tania Singer

The ability to share the other's feelings, known as empathy, has recently become the focus of social neuroscience studies. We review converging evidence that empathy with, for example, the pain of another person, activates part of the neural pain network of the empathizer, without first hand pain stimulation to the empathizer's body. The amplitude of empathic brain responses is modulated by the intensity of the displayed emotion, the appraisal of the situation, characteristics of the suffering person such as perceived fairness, and features of the empathizer such as gender or previous experience with pain-inflicting situations. Future studies in the field should address inter-individual differences in empathy, development and plasticity of the empathic brain over the life span, and the link between empathy, compassionate motivation, and prosocial behavior.

Address
University of Zurich, Center for the Study of Social and Neural Systems, Blümlisalpstrasse 10, CH-8006 Zurich, Switzerland

Corresponding author: Hein, Grit (ghein@iew.uzh.ch)

Current Opinion in Neurobiology 2008, **18**:153–158

This review comes from a themed issue on
Cognitive neuroscience
Edited by Read Montague and John Assad

Available online 15th August 2008

0959-4388/$ – see front matter

DOI 10.1016/j.conb.2008.07.012

Introduction

Humans spend a considerable amount of their lives in the company of others, and understanding the feelings of others and their intentions toward us is crucial for appropriate behavior in our social environment. The intriguing question how we understand the other person's mind and how this is reflected in our own neural state has been addressed by a number of recent neuroscience studies. Accumulating evidence has put forward the view that there are at least two different routes to put us in the shoes (the mind) of the other person [1–6]. One route is to share the other person's feelings in an embodied manner, known as empathy (note that a similar embodied simulation was first observed in the domain of motor actions in the monkey [7,8] and human [9] brain). The other route is to cognitively infer about the state of the other person, known as 'theory of mind' [10], 'mentalizing' [11], 'mind-reading' [12], or 'cognitive perspective taking'. Although often occurring in concert, findings from functional magnetic resonance imaging (fMRI) studies suggest that understanding others on the basis of cognitive perspective taking and empathy recruit different neural networks.

Neural correlates of cognitive perspective taking have been reviewed elsewhere [13,14]. In these studies, participants are typically asked to take the perspective of a person shown on a cartoon or described in a story. Brain regions activated by cognitive perspective taking include medial prefrontal regions, the superior temporal sulcus (STS), extending into the parietal lobe (temporo-parietal junction), sometimes also the temporal pole (Figure 1). Empathizing with another person has been shown to be related to different neural networks, mostly including somatosensory and insular cortices as well as limbic areas and anterior cingulate cortex. Empathy for pain, for example, predominately correlates with activation in the anterior insula (AI) and anterior cingulate (ACC).

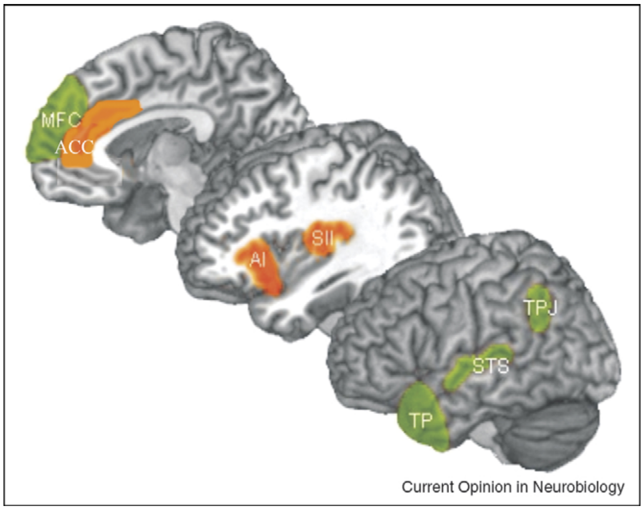
The distinction between cognitive perspective taking and empathy is supported by preliminary evidence from studies of patients with marked social deficits, such as autism or psychopathy. It has been shown that patients with autistic spectrum disorder have a deficit in cognitive perspective taking [15], which might be related to decreased gray matter concentration in the STS region [16]. By contrast, psychopaths seem to have no impairment in cognitive perspective taking, enabling the characteristic manipulative behavior [17]. However, recent studies showed reduced gray matter volume in AI and amygdala [18,19]. Reduced volume in AI correlated to the degree of observed aggressive behavior and empathy in adolescents with conduct disorder [18]. Reduced activity in AI and amygdala was found in psychopaths [19], which might be related to deficits in emotion processing [6,17] and empathy.

In this paper we review recent neuroscientific findings on empathy. First, we define empathy to provide a conceptual framework. Second, we give an overview of paradigms developed to assess empathy with neuroscientific methods, and summarize the main results. A third part focuses on factors that modulate empathic brain responses, and a final part on inter-individual differences in empathy.

What is empathy?

The term empathy is widely used in social and developmental psychology, care-giving settings, sociology, and philosophy, and has been defined in many different ways

Figure 1



Schematic overview of brain regions typically involved in understanding others on the basis of cognitive perspective taking (green) and empathy (orange); the latter measured in the domain of empathic brain responses to pain, disgust, taste, and touch. MPC, medial prefrontal cortex; ACC, anterior cingulate cortex; AI, anterior insula; SII, secondary somatosensory cortex; TP, temporal poles; STS, superior temporal sulcus; TPF, temporo-parietal junction.

[20,21]. From a neuroscientific perspective, it is important to demarcate empathy from cognitive perspective taking on the basis of different neural networks for empathy and cognitive perspective taking outlined in Figure 1 [3]. We refer to cognitive perspective taking as the ability to understand intentions, desires, beliefs of another person, resulting from (cognitively) reasoning about the other's state. By contrast, we refer to empathy as an affective state, caused by sharing of the emotions or sensory states of another person.

Moreover, empathy is distinguished from sympathy [21] (also referred to as empathic concern [22]) or compassion. An affective state elicited by empathy is isomorphic with the other's state, which is not the case for sympathy or compassion [21]. Further, empathy is not necessarily linked to a prosocial motivation, that is, the concern about the others well being, whereas there is such a link from sympathy or compassion to prosociality [21–23]. Empathy can have a dark side, for example when it is used to find the weakest spot of a person to make her or him suffer, which is far from showing compassion with the other. It is suggested that empathy has to be transformed into sympathy [21] or empathic concern [22,23] in order to elicit prosocial motivation. To our knowledge, however, the link between empathy and prosocial behavior has not been explored in depth yet.

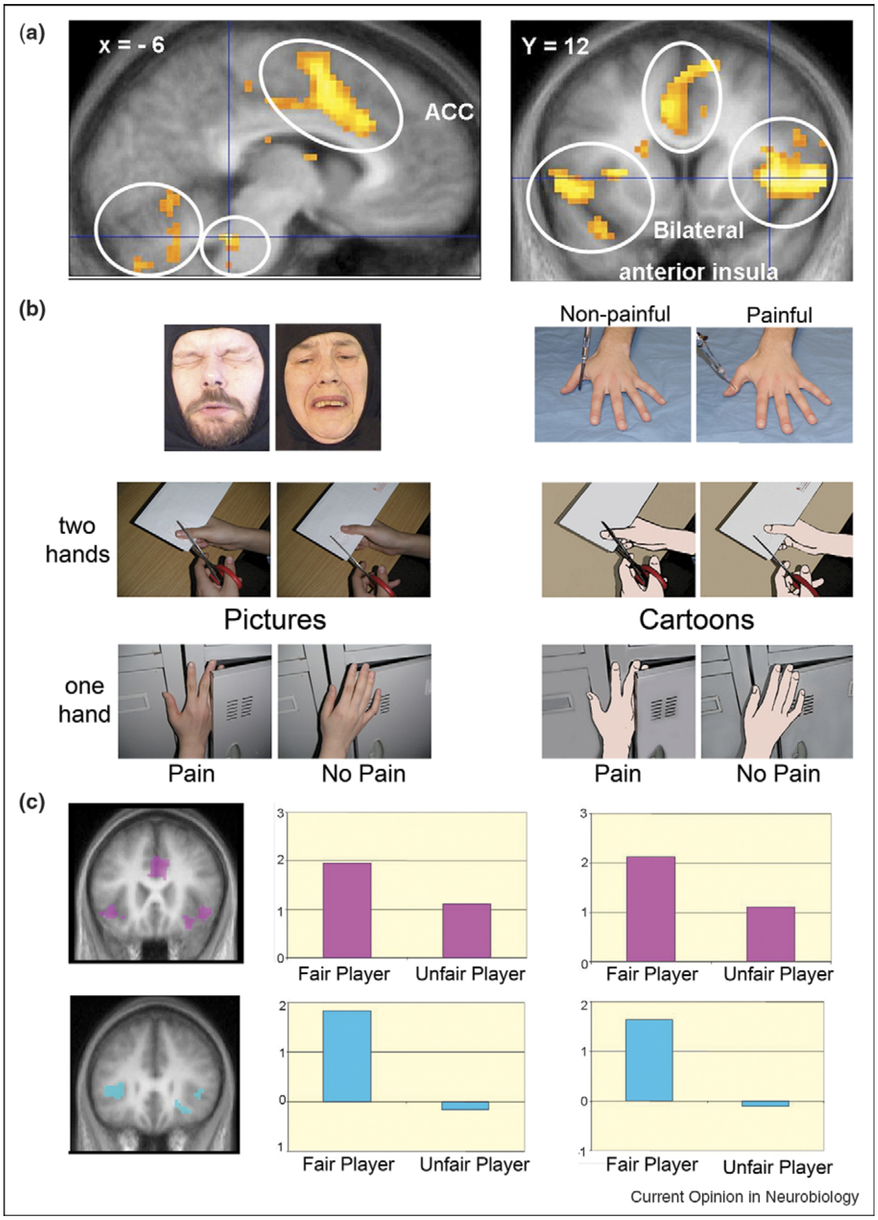
Lastly, empathy has to be separated from emotional contagion. An empathic person is aware of the fact that his or her own affective state is vicariously elicited by the state of the person he or she emphasizes with [3]. Emotional contagion might be a precursor of the development of a capacity for empathy [24], but is not considered an empathic response, because the person incorporates affective states of another person, without being aware that it is not its own feeling.

Neural correlates of empathy

The majority of neuroscience studies on neural correlates of empathy have addressed empathy for pain perceived in another person [25•,26••,27,28,29••,30–41]. Two fMRI studies by Singer *et al.* [32,33] investigated empathy '*in vivo*' with an interactive empathy for pain paradigm. In this paradigm, the volunteer in the fMRI scanner receives either pain herself or perceives pain in another person, delivered via pain electrodes at the back of the volunteer's or the other person's hand. The other person is sitting next to the fMRI scanner and a mirror system allows the participant inside the scanner to see her own as well as the other's hand lying on a tilted board. Differently colored flashes of light on a screen behind the board point to either the volunteer's or the other person's hand, indicating which of them would receive painful and which would receive non-painful stimulation. This procedure permits to measure pain-related brain activation when pain is applied to the scanned volunteer (felt pain) or to her partner (empathy for pain). An early study [32] used this paradigm to assess empathy in couples. Here, the female partner was the volunteer in the scanner, receiving pain herself or perceiving her husband suffering from pain. The results suggest that parts of the so-called 'pain matrix' – bilateral anterior insula (AI), the rostral anterior cingulate cortex (ACC) (Figure 2a), brainstem, and cerebellum – were activated when she experienced pain herself as well as when she saw the arrow cue indicating that her husband had experienced pain. These areas are involved in the processing of the affective component of pain, that is, how unpleasant the subjectively felt pain is. Thus, both the experience of pain to oneself and the knowledge that the other person is experiencing pain activates the same affective pain circuits, suggesting a neural simulation of the suffering of the other person, in absence of pain stimulation to our own body (see [44] for a review). A more recent study [33] with the interactive empathy for pain paradigm showed that empathic brain responses in AI and ACC are not restricted to a beloved partner, but also occur when an unknown, but likable person is in pain.

FMRI studies on empathy for pain in which participants viewed pictures or videos of painful unknown faces [29••,31] or body parts in painful situations [26••,27,28,30,34,37,41,43] (Figure 2b) have revealed a similar pattern of results, emphasizing that neural simulation of the pain of another person occurs independently

Figure 2



Results and example stimulus material of empathy for pain studies. **(a)** Overlapping brain regions activated for the first hand experience of pain and the perception of pain in the other person (empathy for pain; modified from Singer and colleagues [32]) ACC, anterior cingulate cortex. (**b**) Examples of painful faces ([31] with kind permission from M.V. Saarela), and pictures and cartoons of body parts in painful situations (top [41] with kind permission from C Lamm; bottom [27] with kind permission from S Han) used to investigate empathy for pain. (**c**) Empathic brain responses are modulated by a number of factors. For example, men did not show empathy-related activation in the anterior insula when a person in pain was perceived as unfair (modified from Singer and colleagues [33]).

of the affective link between the empathizer and the person in pain.

In most fMRI studies, effects of empathy for pain have been predominately found in AI and ACC [26••,27,28,29••,31–33,37,41,43]. AI and ACC are also involved in general emotional processing [39] and the affective processing of pain [40] in non-empathy conditions, that is, under conditions of 'first hand' experience of the emotion or sensation. This supports the assumption that empathizing with a specific emotion or sensation of the other activates the neural network underlying this specific emotion or sensation in the empathizer.

Recent studies have shown that such empathic 'simulation effects' can also be found in other brain regions.

Studies using magnetoencephalography (MEG) [38] and somatosenory evoked potentials (SEP) [25•] have revealed that empathy for pain in others also modulates components of brain activity that are generated in primary (SI) and secondary (SII) somatosensory region, that is, areas related to 'flesh-and-bone' experience of pain. Further, muscle-specific motor-evoked potentials (MEPs), induced by transmagnetic stimulation (TMS), were inhibited when participants watched a needle penetrating a specific muscle [35,36]. In line with these findings, a recent fMRI study by Lamm *et al.* [41] showed empathy-related activation in contralateral SI when participants focused on the intensity of pain felt by the other person.

Neural simulation of the other's state or feelings is not restricted to empathy for pain. Empathic responses in other domains involve brain structures, which are recruited if those other specific emotions or sensations are self-experienced. There is, for example, evidence that the observation of touch and the first hand experience of touch activate similar regions in secondary somatosensory cortex [45]. In another recent study, participants watched video clips showing people sampling pleasant and unpleasant tastes, and then experienced the different tastes themselves [46•]. Jabbi and colleagues [46•] found neural activation in anterior insula cortex when people passively watched disgust in another person, and when they were disgusted themselves (see also [47]). It is still an open question whether there are shared activations in self and others in domains like joy or sorrow.

Modulation of empathy

The results reviewed above indicate that our brain is set up to simulate the feelings of others, that is, to empathize. However, from our own experience we know that we empathize with others to varying degrees. Recent studies have assessed factors modulating empathic brain responses. One first factor is the intensity of the stimulation or displayed emotion. Saarela *et al.* [31] manipulated the intensity of perceived pain in others by presenting faces of patients being in chronic or acute pain (Figure 2b, upper panel, left). The results showed stronger activations in AI and ACC when participants empathized with people in acute pain as compared with chronic pain. In a study by Avenanti *et al.* [36], participants perceived a needle deeply penetrating body parts of a human model, rated as high intensity of pain, or just scratching the surface of the skin, rated as low pain intensity. Empathy-related inhibition of muscle evoked potentials, following TMS, were found in the high intensity condition, but not in the low intensity condition [36]. A second modulating factor is features of the empathy target, for example, the person being in pain. One recent study showed that empathic brain responses in men but not women were significantly weaker when the person in pain was judged as unfair, as compared with a person seen as fair and likable [33] (Figure 2c). As a third factor, the situational context was found to modulate empathy. Empathic brain responses were reduced when participants were convinced that the other received pain as a therapeutic mean and the therapy was successful rather than in vain [29••]. Moreover, empathic brain responses are modulated by attention. Observing pictures or cartoons of hands in painful situations (Figure 2b, lower panel), participants showed stronger activation in AI and ACC when they focused on the intensity of the other's pain as compared with when they were asked to count the number of hands, that is, shifting attention away from the other's pain [27]. Finally, characteristics of the empathizer were found to affect the strength of empathic brain responses. Cheng *et al.* [26••] showed animated pictures of needles, being inserted in different body parts, to physicians who practice acupuncture, and to naïve participants. The results revealed less empathy-related pain activity in AI, ACC, and regions of interest in the somatosensory cortex in the physicians as compared with the control group, indicating a reduction of empathic brain responses if the empathizer is frequently exposed to pain-inflicting situations. Another recent study [42] used laser-evoked potentials (LEP) and had participants observe painful or non-painful stimulation of another person while suffering from pain themselves. The results showed that the N1/P1 component, probably generated in a region corresponding to SII, was modulated by the rating of the self-pain, rather than the pain of the other person. This led the authors to conclude that empathizers in pain bias their neural empathic responses in a self-centered manner [42]. Moreover, difficulties in identifying and describing own feelings and bodily sensations, known as alexithymia, were found to correlate with a reduction of empathy [48,49]. Moriguchi *et al.* [48] had participants watch hands and feet in painful situations. They reported reduced activation in ACC, dorsolateral prefrontal cortex, and cerebellum, accompanied by low scores in empathy questionnaires, for participants categorized as high alexithymic as compared with a low alexithymic control group.

Inter-individual differences in empathy

Apart from the factors modulating empathy summarized above, there is evidence for inter-individual differences in empathic brain responses. Such inter-individual differences in neural empathy responses were found to correlate with behavioral trait measures of empathy in empathy questionnaires such as the Empathic Concern Scale of the Interpersonal Reactivity Index (IRI) [50] and the Balanced Emotional Empathy Scale (BEES) [32,33,51]. The higher subjects scored on these questionnaires, the higher was their activation in AI and ACC. Interestingly, Jabbi *et al.* [46•] observed similar correlations between IRI subscales and empathic brain responses in the AI for participants who had observed others tasting pleasant or unpleasant drinks associated with facial expressions of joy or disgust alternatively.

Empathic brain responses are not only positively correlated with trait measures of empathy, but also with unpleasantness ratings given online after each trial of an empathy-inducing condition [29••,31,43]. Future research will have to clarify where these individual differences in empathic brain responses stem from and whether and how they predict sympathy and compassion, which then might explain individual differences in prosocial behavior.

Conclusion

Recent neuroscience studies have given insights into brain regions related to empathy, in particular to empathy for the suffering of another person. The results indicate that empathy with feelings of the others, and self-experience of this feeling state recruit shared neural networks, suggesting a simulation of the other's state in the brain of the empathizer. The strength of the empathic brain responses can be modulated by a variety of factors, including the intensity of the displayed emotion, contextual appraisal, features of the empathizer, and of the target of empathy. The reviewed findings have substantially contributed to the understanding of the neural underpinnings of empathy. At the same time, they are a stepping stone for the investigation of important issues in future studies. One first interesting question concerns the basis of inter-individual differences in the ability to emphasize. Plausible sources of inter-individual variation in empathy might be genetic, environmental, or developmental factors, none of which has been sufficiently investigated in the context of neuroscientific empathy research. A second big issue is the link between empathic brain responses and sympathy or compassion, that is, feeling *as* and feeling *for* the other. Thirdly, it is an open question how empathic brain responses relate to prosocial motivation and behavior and finally, almost nothing is known about the plasticity of the empathic brain, that is, about the trainability of empathy and compassionate motivation, all issues that should have considerable practical impacts on society.

Acknowledgements

This work was supported by Society in Science – The Branco Weiss Fellowship to GH, and the UFSP "Foundations of Human Social Behaviour".

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

1. Blair RJ: **Responding to the emotions of others: dissociating forms of empathy through the study of typical and psychiatric populations**. *Conscious Cogn* 2005, **14**:698-718.
2. Decety J, Lamm C: **Human empathy through the lens of social neuroscience**. *Scientific World Journal* 2005, **6**:1146-1163.
3. de Vignemont F, Singer T: **The empathic brain: how, when, and why?** *Trends Cogn Sci* 2005, **10**:435-441.
4. Keysers C, Gazzola V: **Integrating simulation and theory of mind: from self to social cognition**. *Trends Cogn Sci* 2007, **11**:194-196.
5. Preston SD, de Waal FB: **Empathy: its ultimate and proximate bases**. *Behav Brain Sci* 2002, **25**:1-20.
6. Singer T: **The neuronal basis and ontogeny of empathy and mind reading: review of literature and implications for future research**. *Neurosci Biobehav Rev* 2006, **30**:855-863.
7. Gallese V, Fadiga L, Fogassi L, Rizzolatti G: **Action recognition in the premotor cortex**. *Brain* 1996, **119**:593-609.
8. Rizzolatti G, Fadiga L, Gallese V, Fogassi L: **Premotor cortex and the recognition of motor actions**. *Cogn Brain Res* 1996, **3**:131-141.
9. Grezes J, Decety J: **Functional anatomy of execution, mental simulation, observation, and verb generation of actions: a meta-analysis**. *Hum Brain Mapp* 2001, **12**:1-19.
10. Premack D, Woodruff G: **Does the chimpanzee have a theory of mind?** *Behav Brain Sci* 1978, **1**:515-526.
11. Frith U, Frith CD: **Development and neurophysiology of mentalizing**. *Philos Trans R Soc Lond B Biol Sci* 2003, **358**:459-473.
12. Baron-Cohen S: **Mindblindness: An Essay on Autism and Theory of Mind** Cambridge, MA: MIT Press; 1995.
13. Frith CD, Frith U: **The neural basis of mentalizing**. *Neuron* 2006, **50**:531-534.
14. Saxe R: **Uniquely human social cognition**. *Curr Opin Neurobiol* 2006, **16**:235-239.
15. Frith CD, Frith U: **The self and its reputation in autism**. *Neuron* 2008, **57**:331-332.
16. Zilbovicius M, Meresse I, Chabane N, Brunelle F, Samson Y, Boddaert N: **Autism, the superior temporal sulcus and social perception**. *Trends Neurosci* 2006, **29**:259-366.
17. Blair RJ: **Fine cuts of empathy and the amygdala: dissociable deficits in psychopathy and autism**. *Q J Exp Psychol* 2008, **61**:157-170.
18. Sterzer P, Stadler C, Poustka F, Kleinschmidt A: **A structural neural deficit in adolescents with conduct disorder and its association with lack of empathy**. *Neuroimage* 2007, **37**:335-342.
19. Birbaumer N, Veit R, Lotze M, Erb M, Hermann C, Grodd W, Flor H: **Deficient fear conditioning in psychopathy: a functional magnetic resonance imaging study**. *Arch Gen Psychiatry* 2005, **62**:799-805.
20. Decety J, Batson CD: **Social Neuroscience approaches to interpersonal sensitivity**. *Soc Neurosci* 2007, **2**:151-157.
21. Eisenberg N: **Empathy-related responding and prosocial behaviour**. *Novartis Found Symp* 2007, **278**:71-80.
22. Batson CD, Eklund JH, Chermok VL, Hoyt JL, Ortiz BG: **An additional antecedent of empathic concern: valuing the welfare of the person in need**. *J Pers Soc Psychol* 2007, **93**:65-74.
23. Batson CD: **The Altruism Question: Toward a Social–Psychological Answer** Hillsdale, NJ: Erlbaum; 1991.
24. Hoffman ML: **The development of empathy**. In *Altruism and Helping Behavior: Social, Personality, and Developmental Perspectives.* Edited by Rushton JP, Sorrentino RM. Hillsdale, NJ: Erlbaum; 1981:41-63.
25. • Bufalari I, Aprile T, Avenanti A, Di Russo F, Aglioti SM: **Empathy for pain and touch in the human somatosensory cortex**. *Cereb Cortex* 2007, **17**:2553-2561.

Using somatosensory-evoked potentials (SEPs), this study shows an involvement of human primary somatosensory cortex during the observation of pain and touch. Modulations of the P45 component were observed when volunteers rated the intensity of the stimulation of the other, but not when they rated the pleasantness.

26. •• Cheng Y, Lin CP, Liu HL, Hsu YY, Lim KE, Hung D, Decety J: **Expertise modulates the perception of pain in others**. *Curr Biol* 2007, **17**:1708-1713.

This study provides the first evidence that expertise effects and more specifically the experience with pain reduces empathic brain responses in AI and ACC, probably driven by the downregulating influence of medial and superior prefrontal regions on insula activation. The latter was indicated by a significant covariation between activity in medial prefrontal cortex and insula in pain experts, but not in naïve control subjects.

27. Gu X, Han S: **Attention and reality constraints on the neural processes of empathy for pain**. *Neuroimage* 2007, **36**:256-267.

28. Jackson PL, Brunet E, Meltzoff AN, Decety J: **Empathy examined through the neural mechanisms involved in imagining how I feel versus how you feel pain**. *Neuropsychologia* 2006, **44**:752-761.

29. Lamm C, Batson CD, Decety J: **The neural substrate of human
•• empathy: effects of perspective taking and cognitive appraisal**. *J Cogn Neurosci* 2007, **19**:42-58.

This thoroughly conducted study shows that empathic brain responses are modulated by the contextual appraisal of the situation, that is, are reduced when pain is seen as helpful for the other person. Moreover, it is the first fMRI study aiming at disentangling between empathic concern and personal distress.

30. Morrison I, Peelen MV, Downing PE: **The sight of others' pain modulates motor processing in human cingulate cortex**. *Cereb Cortex* 2007, **17**:2214-2222.

31. Saarela MV, Hlushchuk Y, Williams AC, Schürmann M, Kalso E, Hari R: **The compassionate brain: humans detect intensity of pain from another's face**. *Cereb Cortex* 2007, **17**:230-237.

32. Singer T, Seymour B, O'Doherty J, Kaube H, Dolan RJ, Frith CD: **Empathy for pain involves the affective but not sensory components of pain**. *Science* 2004, **303**:1157-1162.

33. Singer T, Seymour B, O'Doherty JP, Stephan KE, Dolan RJ, Frith CD: **Empathic neural responses are modulated by the perceived fairness of others**. *Nature* 2006, **439**:466-469.

34. Morrison I, Downing PE: **Organization of felt and seen pain responses in anterior cingulate cortex**. *Neuroimage* 2007, **37**:642-651.

35. Avenanti A, Bueti D, Galati G, Aglioti S: **Transcranial magnetic stimulation highlights the sensorimotor side of empathy for pain**. *Nat Neurosci* 2005, **8**:955-960.

36. Avenanti A, Paluello IM, Bufalari I, Aglioti SM: **Stimulus-driven modulation of motor-evoked potentials during observation of others' pain**. *Neuroimage* 2006, **32**:316-324.

37. Ogino Y, Nemoto H, Inui K, Saito S, Kakigi R, Goto F: **Inner experience of pain: imagination of pain while viewing images showing painful events forms subjective pain representation in human brain**. *Cereb Cortex* 2006, **17**:1139-1146.

38. Cheng Y, Yang CY, Lin CP, Lee PL, Decety J: **The perception of pain in others suppresses somatosensory oscillations: a magnetoencephalography study**. *Neuroimage* 2008. online.

39. Olsson A, Ochsner KN: **The role of social cognition in emotion**. *Trends Cogn Sci* 2008, **12**:65-71.

40. Craig AD: **How do you feel? Interception: the sense of the physiological condition of the body**. *Nat Rev Neurosci* 2002, **8**:655-666.

41. Lamm C, Nusbaum HC, Meltzoff AN, Decety J: **What are you feeling? Using functional magnetic resonance imaging to assess the modulation of sensory and affective responses during empathy for pain**. *PlOS ONE* 2007:12.

42. Valeriani M, Betti V, LePera D, DeArmas L, Miliucci R, Restuccia, Avenanti A, Aglioti SM: **Seeing the pain of others while being in pain: a laser-evoked potentials study**. *Neuroimage* 2008. online.

43. Jackson PL, Meltzoff AN, Decety J: **How do we perceive the pain of others? A window into the neural processes involved in empathy**. *Neuroimage* 2005, **24**:771-779.

44. Jackson PL, Rainville P, Decety J: **To what extent do we share the pain of others? Insight from the neural bases of pain empathy**. *Pain* 2006, **125**:5-9.

45. Keysers C, Wicker B, Gazzola V, Anton JL, Forgassi L, Gallese V: **A touching sight: SII/PV activation during the observation and experience of touch**. *Neuron* 2004, **42**:335-346.

46. Jabbi M, Swart M, Keysers C: **Empathy for positive and negative
• emotions in the gustatory cortex**. *Neuroimage* 2007, **34**:1744-1753.

An interesting and original study, which investigated for the first time not only negative but also positive empathic emotions, using pleasant and disgusting tastes. Pleasant and disgusting tastes sampled by the volunteers themselves or perceived in other people correlated to overlapping activation in AI and adjacent frontal operculum (IFO). Empathic IFO activity correlated with trait measures of empathy (IRI) scores.

47. Wicker B, Keysers C, Plailly J, Royet JP, Gallese V, Rizzolatti G: **Both of us disgusted in my insula: the common neural basis of seeing and feeling disgust**. *Neuron* 2003, **40**:655-664.

48. Moriguchi Y, Decety J, Ohnishi T, Maeda M, Mori T, Nemoto K, Matsuda H, Komaki G: **Empathy and judging other's pain: an fMRI study of alexithymia**. *Cereb Cortex* 2007, **17**:2223-2234.

49. Silani G, Bird G, Brindley R, Singer T, Frith C, Frith U: **Levels of emotional awareness and autism: an fMRI study**. *Soc Neurosci* 2008, **3**:97-112.

50. Davis MH: **Measuring individual differences in empathy: evidence for a multidimensional approach**. *J Pers Soc Psychol* 1983, **44**:113-126.

51. Mehrabian A, Epstein N: **A measure of emotional empathy**. *J Pers* 1972, **40**:525-543.