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Review article

The role of shared neural activations, mirror neurons, and morality in empathy – A critical comment

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ABSTRACT

In the last decade, the phenomenon of empathy has received widespread attention by the field of social neuroscience. This has provided fresh insights for theoretical models of empathy, and substantially influenced the academic and public conceptions about this complex social skill. The present paper highlights three key issues which are often linked to empathy, but which at the same time might obscure our understanding of it. These issues are: (1) shared neural activations and whether these can be interpreted as evidence for simulation accounts of empathy; (2) the causal link of empathy to our presumed mirror neuron system; and (3) the question whether increasing empathy will result in better moral decisions and behaviors. The aim of our review is to provide the basis for critically evaluating our current understanding of empathy, and its public reception, and to inspire new research directions.

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Empathy is a complex social phenomenon whose many facets have fascinated scholars from various fields and laymen for centuries. Only recently, the field of Social Neuroscience has begun to shed light on the neural underpinnings of this phenomenon. A dominant part of this growing understanding can certainly be attributed to the increased availability and precision of neuroimaging methods such as functional magnetic resonance imaging (fMRI). If one were to trace back the "birthday" of the social neuroscience of empathy, one would certainly end up at the seminal fMRI study by Singer and colleagues (Singer et al., 2004) which showed that experiencing pain and empathizing with the pain of others evoke overlapping neural activations in cingulate and insular cortices. This study not only attracted enormous public and scientific interest (with over 1200 citations by peer-reviewed ISI-listed journals, at the time of writing this article), but also helped to jumpstart the field of social neuroscience, which was then still in its infancy but now has become one of the most thriving fields of neuroscientific

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inquiry. Since this publication, about 10 years ago (and the publication of other equally influential papers around the same time: Decety and Jackson, 2004; Jackson et al., 2005; Morrison et al., 2004; Preston and de Waal, 2002; Wicker et al., 2003) we have seen a tremendous increase in scientific publications revolving around the question of the neural computations and networks that enable us to share the feelings of others. As shown by a Pubmed search of ["empathy" and ("brain" or "neural" or "neuroscience")], performed on September 18, 2014, the handful of papers available in 2004 have now increased to 1300 listed papers, with 2245 of these papers published within the preceding year.

The goal of the present review is not, however, to provide an exhaustive summary of what we have learned from these investigations. For this, a correspondingly high number of recent reviews are available (e.g. Bernhardt and Singer, 2012; Decety et al., 2012; Keysers and Gazzola, 2014a; Shamay-Tsoory, 2011; Singer and Lamm, 2009; Zaki and Ochsner, 2012). Rather, in our extended commentary, we would like to put the spotlight on three issues that in our view currently encumber the field of empathy research. Our intention is not so much an in-depth scientific discourse on these issues, or to criticize the field, since most likely most of our colleagues are equally aware of them, or see them in a very similar way. Rather, we aim to provide some basis for a discussion on how to overcome some common misconceptions and their implications, targeting also science communicators and the interested public who in their enthusiasm have at times misinterpreted and miscommunicated the insights on empathy generated by social neuroscience.

The three issues we discuss are (a) the functional interpretation of shared neural activations and what they tell us about the mechanisms of empathy; (b) the role of mirror neurons in empathy; and (c) the relationship of empathy with morality. In order to give some context to our arguments, we first briefly summarize some of the main insights generated by the neuroscientific study of empathy.

1. The neural networks involved in empathy

One of the major conceptual findings of Singer et al.'s "seed study", which was probably also one of the reasons it had such a strong impact, was the observation that empathy recruits similar neural networks as the direct experience of the emotion one is showing empathy for. Confirming similar work in the domain of disgust (Wicker et al., 2003), their study showed that the anterior insular (AI) cortex and the anterior midcingulate cortex (aMCC according to Vogt, 2005 but in some studies and in most initial work referred to as anterior cingulate cortex, ACC) were activated when observing the pain of others. This finding has since been confirmed by numerous subsequent studies, as documented by image-based and coordinate-based meta-analyses which have quantitatively integrated and summarized the available data (Fan et al., 2011; Lamm et al., 2011). Notably, AI and aMCC are part of the so-called pain neuromatrix, the network of brain areas that is activated when one undergoes painful stimulation oneself (Derbyshire, 2000). Resemblance between neural activity during direct emotion experiences and specific aspects of empathy (in particular motor resonance, see discussion below) was also observed in studies using other methods, such as electroencephalography (EEG), motor evoked potential transcranial magnetic stimulation (MEP-TMS), and even presurgical intracranial electrophysiology (e.g. Avenanti et al., 2005; Bufalari et al., 2007; Hutchison et al., 1999; Perry et al., 2010). The similarity between neural activations for self- and other-related emotion experiences has motivated the interpretation that recruiting mental representations that normally underlie direct emotion experiences is a central mechanism enabling empathy and affective resonance. In other words, it has been suggested that we are able to understand and share the emotions of others by (partially) processing them with our very own emotion system(s). This has also fostered interpretations placing processes such as simulation and self-projection at the core of empathy – mechanisms of empathy that had already been proposed before the availability of functional neuroimaging evidence (Gallese and Goldman, 1998). Importantly, this view of empathy as a simulative process did not emerge in a vacuum. Rather, it was influenced by similar findings and interpretations in the motor domain, such as the discovery of mirror neurons, and claims that these neurons, which fire both when the individual performs an action and when it observes its execution by others, lie at the root of understanding others' actions (see Ferrari and Rizzolatti, 2014, for a recent review). Similarly, in social cognition, simulation and self-projection have been interpreted repeatedly as core mechanism of mentalizing, i.e., considering others' beliefs, intentions or thoughts (Goldman and Sebanz, 2005; Mitchell, 2009). We will critically discuss these claims and the available evidence for it below.

2. Different mechanisms and neural routes to empathy

Empathy has come in (too) many different definitions and descriptions – and this has certainly also infected the field of social neuroscience (see Batson, 2011, for an excellent overview). Yet, several social neuroscientists have argued for a definition that requires at least a partial, isomorphic sharing of the feeling(s) of another person to be classified as empathy (e.g. Bernhardt and Singer, 2012; Decety and Lamm, 2006; Decety et al., 2012; Gonzalez-Liencres et al., 2013; Singer and Lamm, 2009). From the viewpoint of social neuroscience, this interpretation is mainly based on the fact that AI and MCC are brain structures associated with the affective-motivational aspects of pain, Outside of the domain of pain, these areas are associated with functions strongly linked to emotional experiences as well – such as conjoint interoception and homeostatic regulation (Medford and Critchley, 2010). To understand the neuro-psychological mechanisms of empathy, it is not sufficient to focus on its affective components, though. Indeed, numerous investigations have consistently shown that motor and cognitive functions play important roles in the instigation and modulation of empathy. For instance, observing someone else getting his hand jammed in a door or cutting his finger (Jackson et al., 2005, 2006), getting an injection in his hand, or undergoing acupuncture (e.g. Avenanti et al., 2005; Cheng et al., 2007; Lamm et al., 2007b; Perry et al., 2010) has been shown to elicit "motor resonance" processes, which in turn may trigger the affective response to the other's pain. Notably, early but influential models of empathy had already proposed the notion of a tight perception-action coupling in the brain, and the automatic motor resonance resulting from it, as a core mechanism subserving empathy (Preston and de Waal, 2002). Likewise, observing others being touched engages our somatosensory system, seemingly enabling us to code the affective qualities of vicariously perceived touch (see Bufalari and Ionta, 2013; Keysers et al., 2010 for reviews). In the cognitive domain, the ability to deliberately adopt the perspective of others and to imagine their feelings, even without direct observation, can be an equally potent instigator of affective responses (Jackson et al., 2006; Lamm et al., 2007a) and ensuing prosocial behaviors (Hein et al., 2010, 2011). This capacity has mainly been assigned to brain structures associated with theory of mind and mentalizing, such as the medial prefrontal cortex, precuneus, and temporo-parietal junction (e.g. Shamay-Tsoory, 2011), i.e., with processes that are primarily engaged when reflecting on non-affective mental states of others.

These observations have led to the introduction of terms such as motor empathy and cognitive empathy, pitting them against affective empathy. However, it seems more useful in terms of