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Perceived trustworthiness shapes neural empathic responses toward others' pain

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ABSTRACT

As might be expected, neural empathic responses toward someone in pain are shaped by the affective/social relationship between the observer and the suffering person. Brain activity associated with empathy is sensitive to previous knowledge on the other's social conduct, such that, for instance, an unfair person in pain elicits in the observer reduced activations of empathy-related brain regions compared to a fair person. We conjectured that even in the absence of information on the personality and social behavior of an individual, empathy might be modulated by the 'first impression' based on other's physical facial features, such that the other is perceived as trustworthy or untrustworthy. By means of event-related potentials technique, we monitored in two experiments the neural empathic responses associated with the pain of trustworthy and untrustworthy faces, either computerized and parametrically manipulated (Experiment 1) and real faces (Experiment 2) in a cue-based paradigm. We observed P3 empathic reactions towards individuals looking trustworthy whereas the reactions towards individuals looking untrustworthy were negligible, if not null. An additional experiment (Experiment 3) was conducted in order to substantiate our conclusions by demonstrating that the experimental paradigm we designed did very likely activate an empathic response.

1. Introduction

1.1. Empathy

Empathy is an ability of utmost importance for social interactions that acts as a powerful social binding agent. In the last decade, the leading corpus of work in this field mainly relied on functional magnetic resonance imaging (fMRI) demonstrating that this capacity is deeply rooted in the human brain allowing an individual to rapidly share both affective and sensory-motor facets of other people's internal states (i.e., experience sharing) – as advocated by the involvement of mirror neuron and limbic systems (e.g., Keysers et al. (2010), Lamm and Singer (2010) and Rizzolatti and Sinigaglia (2010)) – and to explicitly consider/understand their states – one facet associated with brain regions notoriously involved in mentalizing (or theory of mind) tasks, usually referred to as cognitive empathy, including prefrontal cortical circuitries, temporal structures and precuneus (e.g., Bruneau et al. (2012), Decety and Jackson (2006), Decety and Lamm (2006), Lamm et al. (2011), Saxe and Kanwisher (2003); see Bernhardt and Singer (2012), Zaki and Ochsner (2012) and Gonzalez-Liencres et al. (2013), for reviews on the neuroscience of empathy). Work investigating the temporal aspects of empathy towards others' pain by means of the event-related potential (i.e., ERP) approach consistently showed a positive shift of scalp-recorded electrical activity when participants were presented with painful stimulation applied to others (e.g., needle pricks in different parts of a human hand or cheek) or with painful expressions relative to neutral stimulation (e.g., Q-tip touch of different parts of a human hand or cheek) or neutral expressions (e.g., Decety et al. (2010), Fan and Han (2008), Li and Han (2010), Sheng and Han (2012), Sheng et al. (2015), Sessa et al. (2014a) and (2014b) in variable temporal windows on the basis of the task at hand, encompassing P2, N2, N3 and P3 ERP components. Sessa et al. (2014b) provided direct evidence for temporally and functionally separable ERP reactions. They showed that a pictorial cue, i.e. a painful facial expression, selectively activated an empathic reaction observed in a time window including the P2 component and the N2–N3 complex; a cognitive cue, i.e. verbal information describing a painful or neutral situation, selectively differentiated electrical activity in a later time window, including the P3 component. These findings strongly suggest that the earlier response

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to pain associated with the P2, N2 and N3 components reflects a more automatic empathic response linked to the experience sharing component of empathy, whereas the P3 (e.g., Donchin (1981), Donchin and Coles (1988), Sessa et al. (2007) and Verleger (1988, 1997)) response to pain is taken as reflecting the more controlled component of empathy (e.g., see also Decety et al. (2010), Li and Han (2010); see Fan and Han (2008), for evidence compatible with Sessa et al.'s study). These previous empathy studies, indeed, demonstrated that the P3 reaction to others' pain is strongly depended on task-set (e.g., Fan and Han (2008)) and on the nature of the stimuli triggering the empathic reaction (e.g., Sessa et al. (2014b)). More broadly, in the context of empathy for pain studies, the P3 component is modulated by different types of top-down attention demands (see also Li and Han (2010), Ibáñez et al. (2011), Ikezawa et al. (2014), Cheng et al. (2012) and Meng et al. (2012)). This evidence has been taken as a clear indication that the P3, in particular, reflects the more cognitive component of empathy (see also Zaki and Ochsner (2012)).

A critical feature of empathy, as measured by both neuroimaging and ERPs techniques, is that it may be modulated by social and affective relations between individuals. As it might be expected, people tend to be more empathetic towards similar others – for instance in terms of group membership – or individuals they like (e.g., Avenanti et al. (2010), Chartrand and Bargh (1999), Contreras-Huerta et al. (2014), Eres and Molenberghs (2013), Harris and Fiske (2006), Hein et al. (2010), Meng et al. (2013), Sessa et al. (2014a) and Xu et al. (2009)). In this vein, neural responses associated with empathy are shaped by learned preferences and appraisal of others' social behavior. Singer and colleagues (Singer et al., 2006) have offered an elegant demonstration of this kind of variance in empathy in the context of empathy towards others' pain, providing evidence that painfully stimulated unfair individuals induce in the observers reduced activations of empathy-related brain regions compared to fair individuals. In the first phase of their study, Singer et al. (2006) engaged male and female participants in an economic game (i.e., a sequential Prisoner's Dilemma game), in which two confederates played fairly or unfairly. In the second phase, blood-oxygen-level-dependent (i.e., BOLD) fMRI signal of the same participants was monitored in the context of the so-called cue-based paradigm (see, e.g., Lamm et al. (2011)). A colored arrow indicated whether a painful stimulation (i.e., through electrodes to the hands) would have been applied to themselves (i.e., self condition), to the fair player (i.e., fair condition) or to the unfair player (i.e., unfair condition). Both females and males exhibited reduced activation of empathy-related brain regions (including anterior insula, fronto-insular cortex and anterior cingulate cortex) towards unfair players but this reduction was particularly evident in men.[2] Taken together, these findings very clearly confirmed the view that previous knowledge of someone else is a significant source of information that biases downstream processes, critically including empathy towards others' pain.

1.2. *Perceived trustworthiness*

However, is previous knowledge of someone's fair/unfair social conduct an essential source of information for shaping people's empathic responses? Indeed, people immediately form impressions of others on first meeting on the basis of others' physical appearance and immediately like or dislike them adjusting their behavior even in the absence of previous knowledge of others' personality and social behavior. Evaluation of a stranger as trustworthy or untrustworthy is one of these appraisals 'at first sight' taking only a fraction of a second (e.g., Bar et al. (2006), Marzi et al. (2014), Todorov et al. (2011) and Willis and Todorov (2006)). A large body of behavioral research has individuated physical characteristics that guide people in trustworthiness evaluation (e.g., Knutson (1996), Montepare and Dobish (2003), Oosterhof and Todorov (2008) and Todorov et al. (2008)). Compelling advancement in this field has been provided by the work by Oosterhof and Todorov (2008) who individuated facial features that people use to appraise others' trustworthiness: faces appearing trustworthy are characterized by high inner eyebrows, pronounced cheekbones, wide chins and shallow nose sellion, while faces perceived as untrustworthy are characterized by low inner eyebrows, shallow cheekbones, thin chins and deep nose sellion. However, other studies have individuated additional elements from faces linked to trustworthiness judgments. For instance Stirrat and Perrett (2010) have found that facial-width ratio manipulated with computer graphics modulated attributions of trustworthiness. Interestingly, at least for perceived trustworthiness related to facial-width ratio, this appraisal seems to produce reliable evaluation for social interactions in the real life: indeed, individuals perceived as untrustworthy do tend to exploit the trust of others in social and economic exchanges (Stirrat and Perrett, 2010). Furthermore, in a recent ERP study conducted in our laboratory, we demonstrated that trustworthiness of a face is implicitly appraised even if task-irrelevant when individuals have to memorize face identity modulating neural measures of visual working memory representation of the face (Meconi et al., 2014).

1.3. *Current study*

The ongoing considerations led us to hypothesize that, even when information on others' social behavior is lacking, empathy may be shaped solely by this first impression. In particular, we conjectured that individuals perceived as trustworthy would have induced in the observer a greater neural reaction to their pain when compared with individuals perceived as untrustworthy, similarly to individuals known to be fair/unfair (see Singer et al. (2006)). By means of ERPs technique, we monitored neural reactions towards painful and non-painful stimulation associated with trustworthy and untrustworthy individuals in two experiments using both computerized bald male faces parametrically manipulated on the trustworthiness dimension (Experiment 1) and real male faces[3] rated on the trustworthiness dimension by an independent sample of participants (Experiment 2). An additional experiment (Experiment 3) was conducted in order to substantiate our conclusions by demonstrating that the experimental paradigm we designed did very likely activate an empathic response.

We implemented a variant of the pain decision task (e.g., Xu et al. (2009) and Sessa et al. (2014a)) in which participants, in each experimental trial, were first exposed to a face looking either trustworthy or untrustworthy, and following a short blank interval, a pictorial cue (either a syringe or a Q-tip) indicated whether a painful stimulation or a non-painful stimulation was applied to the cheek of that individual, a procedure that was similar to the cue-based paradigm (see Lamm et al. (2011)) implemented in the study by Singer et al. (2006). In our experiments, the colored arrow signaling pain was replaced by the picture of a syringe (the non-

[2] The cue-based paradigm likely involves primarily mentalizing, i.e., the cognitive component of empathy (see, for instance, McCall and Singer (2013)). In this vein, it is plausible that activation of these brain regions (i.e., anterior insula, fronto-insular cortex and anterior cingulate cortex) observed in this kind of paradigm is the result of top-down processing rather than reflecting experience sharing per se.

[3] The importance of the use of naturalistic stimuli in social cognition has been underlined by Zaki and Ochsner (2009). To note, Fan and Han (2008) provided evidence that the contextual reality of stimuli may shape electrophysiological activity by postponing ERP modulations for cartooned stimuli relative to realistic stimuli.