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Empathy and contextual social cognition

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Abstract Empathy is a highly flexible and adaptive process that allows for the interplay of prosocial behavior in many different social contexts. Empathy appears to be a very situated cognitive process, embedded with specific contextual cues that trigger different automatic and controlled responses. In this review, we summarize relevant evidence regarding social context modulation of empathy for pain. Several contextual factors, such as stimulus reality and personal experience, affectively link with other factors, emotional cues, threat information, group membership, and attitudes toward others to influence the affective, sensorimotor, and cognitive processing of empathy. Thus, we propose that the fronto-insular-temporal network, the so-called social context network model (SCNM), is recruited during the contextual processing of empathy. This network would (1) update the contextual cues and use them to construct fast predictions (frontal regions), (2) coordinate the internal (body) and external milieu (insula), and (3) consolidate the context–target associative learning of empathic processes (temporal sites). Furthermore, we propose these context-dependent effects of empathy in the framework of the fronto-insular-temporal network and examine the behavioral and neural evidence of three neuropsychiatric conditions

(Asperger syndrome, schizophrenia, and the behavioral variant of frontotemporal dementia), which simultaneously present with empathy and contextual integration impairments. We suggest potential advantages of a situated approach to empathy in the assessment of these neuropsychiatric disorders, as well as their relationship with the SCNM.

Keywords Empathy · Context-dependent effects · Social cognition · SCNM · Frontoinsular-temporal network · bvFTD · Asperger syndrome · Schizophrenia

Introduction

Empathy—the ability to recognize the feelings of others—is a fundamental component of the human emotional experience and social cognition that influences emotions and behavior (Bernhardt & Singer, 2012; Eslinger, Moore, Anderson, & Grossman, 2011). Despite its obvious importance in everyday life, defining empathy proves difficult because it lacks a universally accepted definition. Here, we consider three levels of analysis: (1) a definition (as an ability), (2) the components (multiple underlying affective and cognitive processes), and (3) a main set of neural regions. The term *empathy* is applied broadly, which covers a spectrum of phenomena ranging from generating feelings of concern for other people to experiencing emotions matching another individual's emotions, knowing what another person is thinking or feeling, and blurring the line between self and other (Decety & Ickes, 2011; J. R. Hodges, 2001).

This ability is a complex phenomenon that can be partially dissociated into different related cognitive processes. As such, empathy can be described as an ability that emerges from various subsets of cognitive processes. Thus, a behavior as complex as empathy involves not only a minimal recognition and understanding of another's emotional state, but also the affective experience of the other person's actual or inferred

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emotional state (Decety & Jackson, 2004). As such, empathy requires both the ability to share the emotional experience of the other person (affective component) and an understanding of the other person's experience (cognitive component) (Decety & Jackson, 2004; Eisenberg & Eggum, 2009; Hodges & Klein, 2001). Empathy involves components automatically elicited by affective arousal, emotional responses, and basic understanding (bottom-up information processing). Moreover, empathy incorporates top-down controlled processes in which the perceiver's motivation, memories, intentions, and attitudes influence the extent of an empathic experience, which is underpinned by the interacting neural system (Decety, 2010; Decety & Lamm, 2006; Decety & Meyer, 2008).

At the neural level, research on the mechanisms that mediate empathy has evidenced a relatively reliable neural network of empathic processes involving the anterior insula (AI), somatosensory cortex, periaqueductal gray (PAG), and anterior cingulate cortex (ACC) (Decety & Jackson, 2004; Decety & Lamm, 2006; Jackson, Rainville, & Decety, 2006). Despite this well-established evidence, it remains unclear whether empathy is a modular or a domain-specific phenomenon. For example, does the perception of others in pain always imply a shared emotional experience? Does the context increase or attenuate the neural processing of empathy?

In imagining a scene of an unprotected child being hurt by an aggressive adult, certainly, we would feel empathic sadness and concern for the victim and anger toward the perpetrator. Nevertheless, the set of feelings, cognitions, and actions related to empathy is strongly dependent on the appropriate processing of the contextual situation. In the above example, our empathic emotion might be different if the victim was an adult and even more different if he/she was an adult with aggressive behavior. By being attacked by the perpetrator, we may feel ourselves at risk, and we can decide to escape or attack. Furthermore, we would feel and act differently depending on when and where (e.g., at home, in the street, or at night) the situation occurs. Also, our feelings about the situation and our own actions may be different depending on whether the perpetrator and/or the victim is an in-group or out-group member. In addition, our possible reaction (e.g., defense, attack, concern, or help) would depend on our own past experience with suffering and bullying and on our own control levels and impulsivity.

Research in cognitive science and social neuroscience has revealed context-dependent effects not only in empathy (as detailed below), but also in the related domains of visual perception (Bar, 2004; Schwartz, Hsu, & Dayan, 2007; Zhang & von der Heydt, 2010), emotion (Barrett & Bar, 2009; Barrett, Lindquist, & Gendron, 2007; de Gelder, 2006; Ibanez, Gleichgerricht, Hurtado, et al., 2010; Ibanez, Hurtado, Riveros, et al., 2011; Meeren, van Heijnsbergen, & de Gelder, 2005), language (Aravena et al., 2010; Cardona et al., 2013; Hagoort,

2005; Hagoort & van Berkum, 2007; Ibanez, Cardona, et al., 2012; Ibanez, Lopez, & Cornejo, 2006; Ibanez, Toro, et al., 2011), and social cognition (Chung, Mathews, & Barch, 2010; Ibanez & Manes, 2012; Rankin et al., 2009) and in both normal and neuropsychiatric conditions. Empathy is not an exception.

Contextual modulation of empathy may represent an adaptive advantage, making behavior more sensitive to different environment conditions. To perform this flexible behavior, our brain must access the available contextual information to predict the social meaning (e.g., others' intentions, feelings, and behavior) on the basis of previous experiences and the relevance of the particular situation. In every empathic process, contextual cues evoke previous experiences allowing for coordination of internal (previous experiences) and external (situation appraisal) processes. Neural correlates of empathy have been reviewed elsewhere (Bernhardt & Singer, 2012; Carter, Harris, & Porges, 2009; Decety, 2010; Lamm, Batson, & Decety, 2007), and other authors have suggested how the situational context could modulate empathy (Hein & Singer, 2008; Singer & Lamm, 2009). However, none have proposed a neural network model that accounts for the role of context in the empathy process. Here, we first review the current research on empathy for pain, highlighting the context-dependent effects at different levels, and we then assess three new outstanding issues:

1. We propose a social context network model (SCNM) of contextual influence on empathy processing that depends on a fronto-insular-temporal network.
2. We suggest that a general deficit in the integration of social context and behavior could at least partially explain the wide range of social cognition impairments of three neuropsychiatric conditions: Asperger syndrome (AS), schizophrenia (SCZ), and the behavioral variant of frontotemporal dementia (bvFTD).
3. Finally, we introduce a more lifelike approach of empathy involving the contextual dependence of real-life scenarios related to the SCNM, which may also provide more sensitive and ecological measures when applied to different neuropsychiatric populations.

Neuroanatomy of empathy

In this section, we highlight the most systematic brain network activation to empathic responses. As we will detail below (in the *Is empathy a context-dependent phenomenon?* section), these regions are systematically modulated by contextual factors.

Like other social cognitive processes (Fig. 1), empathy relies on a large array of brain structures and systems (Carter et al., 2009; Decety, 2010) engaged in different networks of

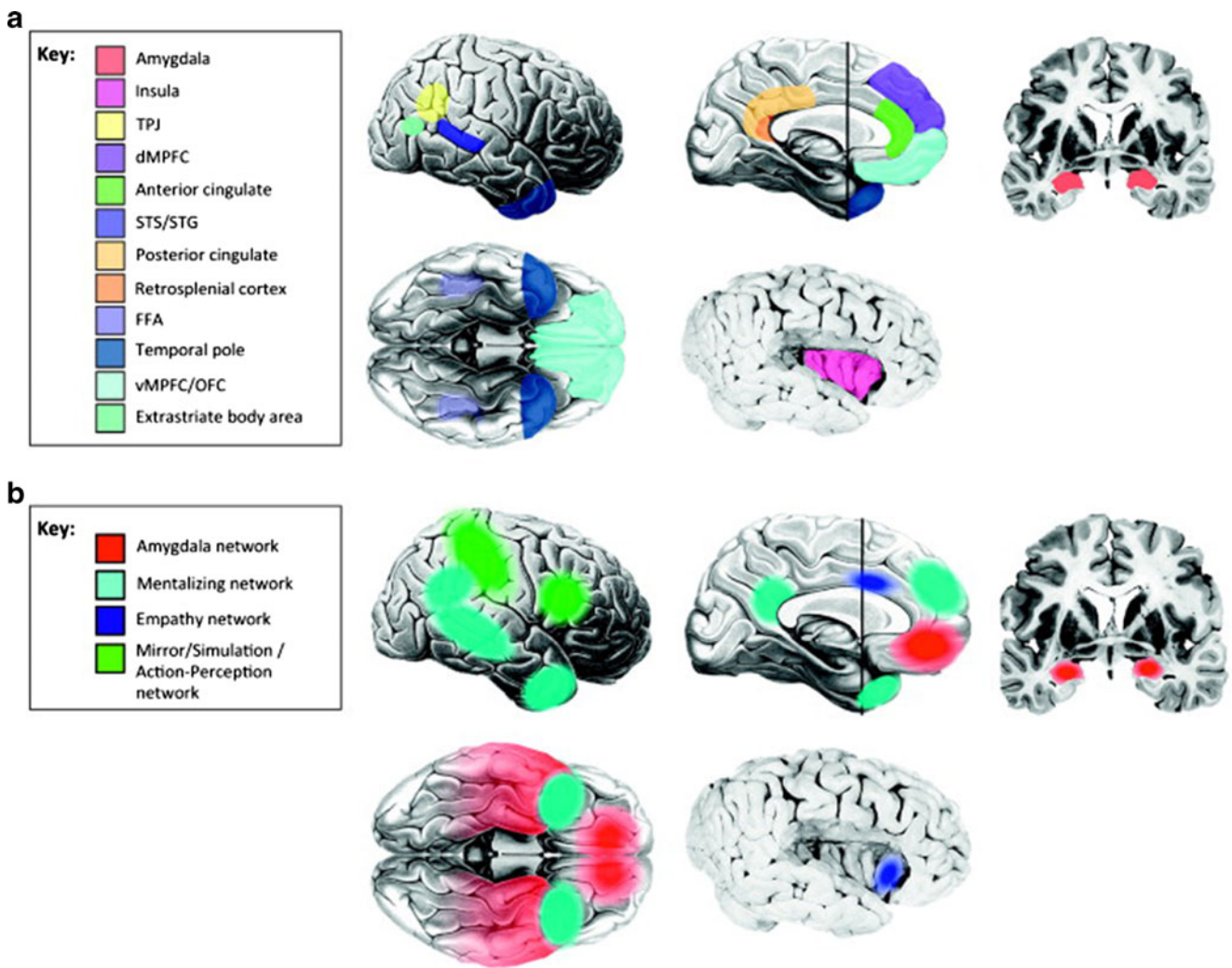


Fig. 1 Social cognition brain structure and network. **a** Structures. Several brain regions are involved in social cognition: TPJ, temporoparietal junction; dMPFC, dorsomedial prefrontal cortex; STS/STG, superior temporal sulcus/gyrus; FFA, fusiform face area; and vMPFC/OFC, ventromedial prefrontal cortex/orbitofrontal cortex. **b** Networks. Several core social cognition networks have been described. Not surprisingly, most of these encompass structures from the original “social brain.” One network is centered on the amygdala (saliency network). A second network is the

the social brain. A number of distinct and interacting neurocognitive components contribute to the experience of empathy: (1) affective arousal, a bottom-up process in which the amygdala, hypothalamus, and orbitofrontal cortex (OFC) underlie rapid and prioritized processing of the emotion signal; (2) emotional understanding, which relies on self- and other-awareness and involves the medial prefrontal cortex (mPFC), ventromedial prefrontal cortex (vmPFC), and temporo-parietal junction (TPJ); and (3) emotion regulation, which depends on executive functions instantiated in the intrinsic corticocortical connections of the OFC, mPFC, and dorsolateral PFC, as well as on the connections with subcortical

so-called mentalizing, or ToM, network. Another network is activated during observation of the actions of others, including their emotional expressions. Finally, the empathy network is highlighted in *blue*. Please note that for simplicity and clarity, not all regions implicated in the networks are shown. Reprinted from “The Social Brain in Psychiatric and Neurological Disorders,” by D. P. Kennedy & R. Adolphs, 2012, *Trends in Cognitive Sciences*, 16, 559–572. Reprinted with permission

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limbic structures implicated in processing emotional information (Decety, 2010).

Empathy for pain has been frequently studied because of the robustness of pain in inducing empathy (Bernhardt & Singer, 2012). As such, the neural circuits involved in pain are relatively well characterized (Apkarian, Bushnell, Treede, & Zubieta, 2005; Bushnell et al., 1999; Craig, 2003; Duerden & Albanese, 2012; Peyron, Laurent, & Garcia-Larrea, 2000; Rainville, 2002). On the basis of the results from these studies, a growing number of neuroimaging investigations have shown that the same neural circuit (the pain matrix) implicated in the experience of physical pain is also involved in the

perception or even the imagination of another individual in pain (Jackson, Brunet, Meltzoff, & Decety, 2006). This neural circuit includes the supplementary motor area (SMA), dorsal ACC, anterior medial cingulate cortex (aMCC), PAG, AI, and amygdala (Akitsuki & Decety, 2009; Lamm et al., 2007). Thus, instead of a domain-specific neural network, it seems that several hubs and networks mainly centered around the IC and ACC are engaged in empathy tasks.

Recent meta-analysis extends the activation of the pain matrix to the inferior frontal gyrus (IFG) and dorsal ACC (Lamm, Decety, & Singer, 2011). Of particular importance, the activation of the AI is most often implicated across all the studies of empathy for pain (Gu et al., 2010). It has been proposed that the AI, through its intimate connections to temporal and frontal regions, serves to index interoceptive balance, which is related to the feeling of pain and emotional awareness (*Handbook of Emotions*, 2008). This insular network plays an important role in the learning and adaptation of prosocial behavior and might guide decision making and homeostatic regulation (Singer, Critchley, & Preusschoff, 2009).

Is empathy a context-dependent phenomenon?

Social cognition processes, including emotional processing, empathy, and decision making, are mostly embedded in a social context (Baez et al., 2013; Ibanez & Manes, 2012; Kennedy & Adolphs, 2012). The ability to recognize, manipulate, and behave with respect to socially relevant information requires neural systems that process the perception of social signals and that connect such perceptions to motivation, emotion, and adaptive behavior (Adolphs, 2001).

Several contextual cue-based studies (see below) have shown a modulation of empathy-related brain responses in frontoinsula regions and have suggested that these regions have an important role in vicarious sharing of many emotions and sensations and may integrate information from a range of different domains to allow the flexible selection of adaptive responses. However, the insular and ACC activation in vicarious emotions does not imply that these regions are the empathy-processing areas per se (Bernhardt & Singer, 2012).

Empathy and contextual modulation networks imply partial but overlapping processes and brain regions. On the one hand, several studies have demonstrated a core activation of AI and ACC during empathy for pain with different paradigms, and these brain responses are modulated by different situational contextual cues. But on the other hand, contextual modulation and its concomitant frontotemporal activation have been observed in several social (Ibanez & Manes, 2012) and nonsocial (Bar, 2004) domains. Moreover, contextual information in general domains impacts both the automatic bottom-up (e.g., Kveraga et al., 2011) and the top-down (e.g., Fogelson &

Fernandez-Del-Olmo, 2013) processing. Consistent with this general two-stage modulation, empathy reports also show both bottom-up (e.g., Ibanez, Hurtado, Lobos, et al., 2011) and top-down (e.g., Gu & Han, 2007) contextual modulation.

In this section, we review very diverse domains that show a systematic influence of contextual effects. As described below, these modulatory effects through a broad range of domains may be accounted for by a common cortical network, the SCNM.

The contextual reality of the stimuli

If empathy for pain is a highly contextual phenomenon, it should be affected by stimulus reality and ambiguity. Visual contextual cues help to bias the meaning of ambiguous targets (Bar, 2004, 2009). In this vein, Gu and Han (2007) found that attention to pain cues and stimulus reality modulate the temporal brain dynamics involved in empathy for pain tasks. Gu and Han designed two tasks in which the hands were in painful or neutral situations. During the painful situation task, subjects were asked to judge the pain intensity of the hand owner. This judgment of pain intensity requires focused attention to the pain cues or counting the numbers of hands that drew attention away from the other's pain. Rating the pain intensity of painful pictures induced an increased activation in parts of the pain matrix, including the ACC, AI, and left middle frontal gyrus. These neural activities were evident in the pain judgment task, but not in the counting task. Additionally, subjects were also presented with cartoons showing hands in similar painful situations to assess the stimuli's authenticity. Rating pain intensity of painful cartoons failed to activate the insula and produced lower ACC activity, suggesting that empathy was also modulated by the contextual reality of the stimulus (Gu & Han, 2007). Furthermore, Fan and Han (2008) investigated the neural activities underlying empathy for pain by recording event related potentials (ERPs) and showed that the early differentiation between the painful and the neutral stimuli found in the frontal-central cortex was modulated by the contextual reality of the stimuli (Fig. 2).

The contextual appraisal of intentionality, emotion, and reward cues

As an adaptive and flexible cognitive process, empathy reactions and their neural correlates should be enhanced or suppressed depending on contextual markers, which directly inform the observer about the other's intentions and the consequences of social behavior.

For instance, the intention to hurt during social interactions modulates the neural response to the perception of pain in others. Akitsuki and Decety (2009) found that empathy for pain was modulated by the social context in which the painful situations occurred (Fig. 3). The ratings of pain intentionally caused by another person were greater than ratings of pain that

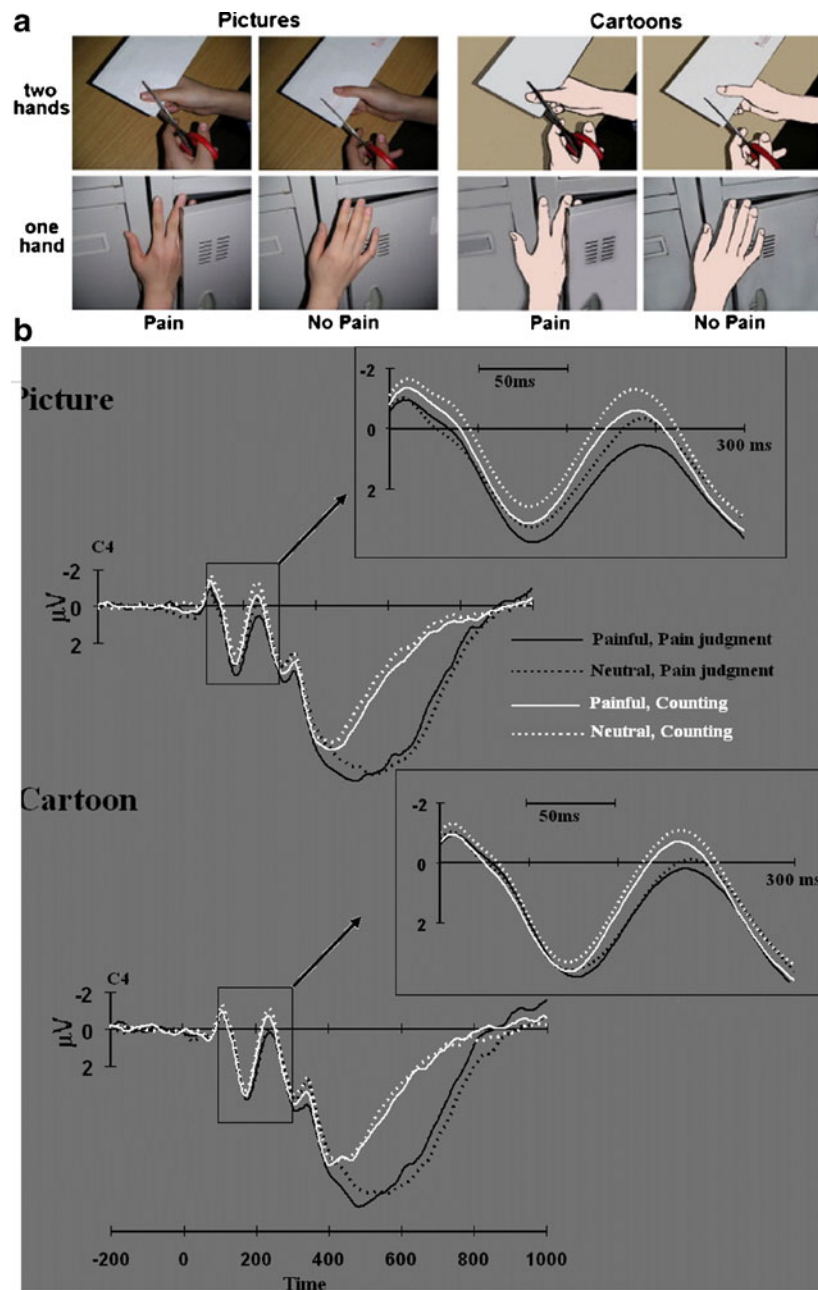


Fig. 2 Early cortical modulation of stimulus reality reflecting the contextual appraisal of empathy. **a** Illustration of the stimuli used in this study. The cartoons were based on the picture of stimuli. **b** Comparison between the early ERP pain effects induced by pictures and cartoons. Adapted

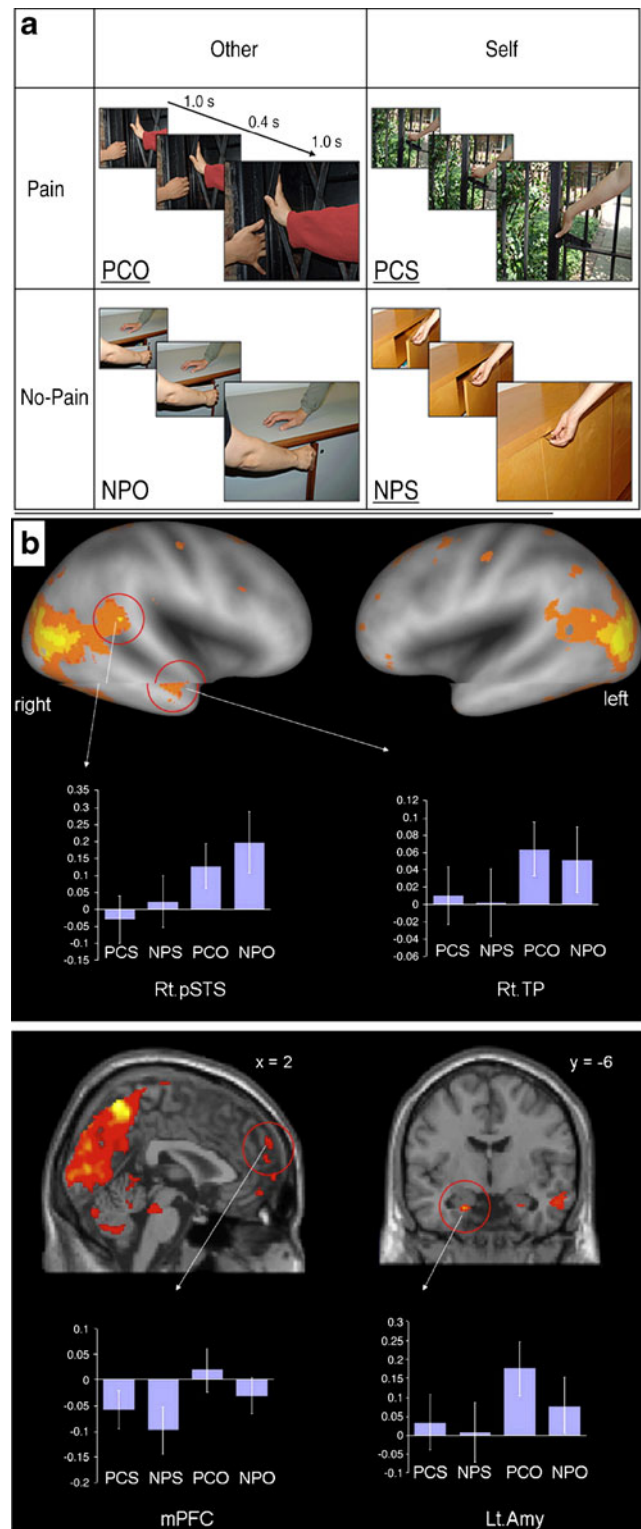
from “Temporal Dynamics of Neural Mechanisms Involved in Empathy for Pain: An Event-Related Brain Potential Study,” by Y. Fan & S. Han, 2008, *Neuropsychologia*, 46, 160–173. Reprinted with permission

was accidentally caused, and hemodynamic signal increase was detected in the amygdala and left IFG (Akitsuki & Decety, 2009). These findings were also replicated in children (Decety, Michalska, & Akitsuki, 2008; Decety, Michalska, & Kinzler, 2012).

In specific contexts, others’ pain may reflect the processing of a threat or negative arousal, rather than being a precursor of empathic prosocial response. In a recent experiment (Yamada & Decety, 2009), likable and unlikable affective words (e.g., honest vs. rude) were subliminally associated with faces, using a

priming technique. Detection of pain was facilitated only by unconscious negative affective processing, and not by positive affective processing (Yamada & Decety, 2009). In another study (Ibanez, Hurtado, Lobos, et al., 2011), two experiments (one with semantic stimuli and the other with images) with neutral or pain expressions previously primed with self (subject) or other faces were presented. Behavioral and ERP responses (N100 and P300) to pain and no-pain were modulated only during the other-face priming condition. This result suggests that pain processing of other-related, but not self-related, information

Fig. 3 Social context modulation of empathy for pain. **a** Examples of the visual stimuli used for each category. Dynamic stimuli consist of three pictures of the same size. PCO, pain caused by another individual; PCS, pain caused by self; NPO, no pain with another individual; and NPS, no pain with self. **b** Main effect of social context: Regions showing a significant main effect of social context (e.g., areas showing greater activation in self and other trials than in self trials). Activation profiles in parameter estimate are also shown for regions of interest (ROIs) in the right posterior part of the superior temporal sulcus (pSTS), right temporal pole (TP), medial prefrontal cortex (mPFC), and left amygdala (Amy). A 2×2 ANOVA was performed for each ROI. There was a significant main effect for social context in each ROI. Adapted from “Social Context and Perceived Agency Affects Empathy for Pain: An Event-Related fMRI Investigation,” by Y. Akitsuki & J. Decety, 2009, *NeuroImage*, 47, 722–734. Reprinted with permission



could imply danger rather than empathy, due to the possible threat represented in the expressions of others (especially when associated with pain stimuli). These results support the threat value of pain hypothesis and suggest that in some circumstances, the processing of others' pain is related to threats, and not to empathy (Coll, Budell, Rainville, Decety, & Jackson, 2012; Ibanez, Hurtado, Lobos, et al., 2011).

Finally, the contextual effects of reward and emotion have been observed in empathy for pain research. An fMRI study (Guo et al., 2012) showed an enhanced brain empathic response (ACC, aMCC, insula, postcentral gyrus, and TPJ) to others in pain when they received no reward, rather than a large reward. The financial situation of the target in pain influenced the neural empathic response. Another fMRI study (Han et al., 2009), using emotional faces in pain and not in pain as stimuli, suggests that observing painful stimuli in an emotional context weakens the affective responses and increases the sensory responses to perceived pain. This study also linked the interactions between the affective and sensory components of the pain matrix.

Attitudes, group membership, and social distance

As an adaptive behavior, empathy for pain should be sensitive to others' closeness. Inferring through a quick and efficient process of how close or relevant the other in pain is to oneself would modulate any emotional response, help to predict the situational outcome, and guide one's own reactions.

One study (Rae Westbury & Neumann, 2008) examined the subjective self-reported empathy ratings, corrugator electromyographic activity, and phasic skin conductance responses (SCRs) during films depicting humans, primates, quadruped mammals, and birds in victimized circumstances. There were higher subjective ratings of empathy and larger SCRs as the stimuli became closer in phylogenetic relatedness to humans. The greater the similarity of the species to humans, the larger the subjective ratings and SCRs become. Likewise, within human interactions (Fig. 4), the degree of other's closeness (a loved person vs. a stranger) modulates the pain matrix activation (Cheng, Chen, Lin, Chou, & Decety, 2010).

Empathic responses and their neural correlates are moderated early by a priori attitudes toward other people (Decety, Echols, & Correll, 2010). Subjects were significantly more sensitive to the pain of individuals who had contracted AIDS as the result of a blood transfusion, as compared with

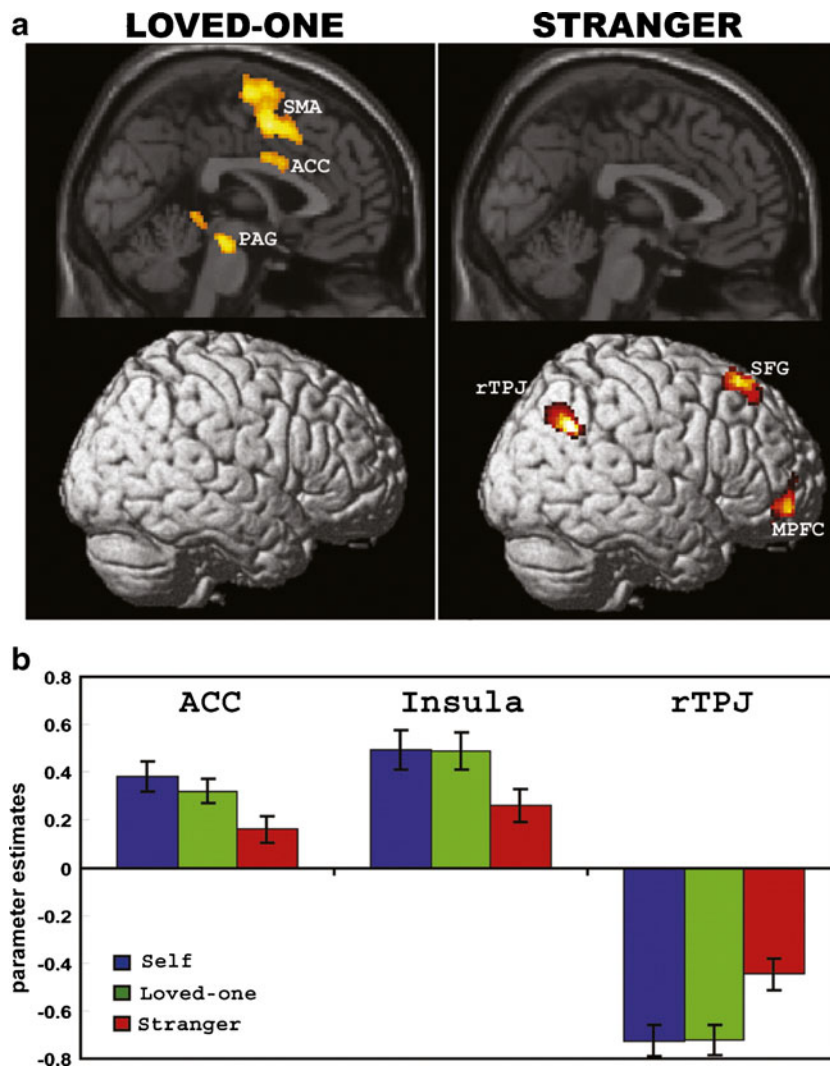


Fig. 4 Pain empathy responses associated with imagining a loved one and a stranger in pain. **a** Double dissociation of pain empathy-related hemodynamic activity in the anterior cingulate cortex (ACC) and right temporo-parietal junction (rTPJ). Imagining a loved one versus a stranger in painful situations was associated with increased activation in the ACC, but not in the rTPJ, while imagining a stranger versus a loved one showed

the opposite pattern. **b** Parameter estimates in the ACC, insula, and rTPJ in each condition. Hemodynamic responses in the ACC, anterior insula, and rTPJ are shown, respectively, for imagining the self, a loved one, and a stranger in painful situations. Reprinted from “Love Hurts: An fMRI Study,” by Y. Cheng, C. P. Lin, K. H. Chou, & J. Decety, 2010, *NeuroImage*, 51, 923–929. Reprinted with permission

individuals who had contracted AIDS as the result of their illicit drug addiction (sharing needles). This sensitivity was evidenced by significantly higher pain and empathy ratings and greater hemodynamic activity in the pain-processing areas (e.g., AI, aMCC, and PAG).

The consideration of fairness for others in pain also modulates the pain matrix (Singer et al., 2006). Subjects were asked to play a game with confederates who performed explicitly fair or unfair strategies. Fronto-insular and dorsal ACC activation during the observation of pictures of others in pain was reduced when “unfair players” received shocks (Fig. 5). This modulation was also affected by the degree of affective sharing, eliciting an enhanced reduction in the male over the female subjects.

Racial group membership (Xu, Zuo, Wang, & Han, 2009) also influences empathic process. Notably, the neural response in the ACC to perception of others in pain decreased when subjects viewed faces of racial out-group members, relative to racial in-group members. Similar effects were reported with different group memberships (Hein, Silani, Preuschhoff, Batson, & Singer, 2010). Moreover, increased nucleus accumbens (NAcc) activation was related to a stronger negative out-group evaluation. Thus, depending on contextual information, some of the regions of the pain matrix activation (e.g., NAcc) would imply an antagonistic motivation to empathy (e.g., revenge feelings or pleasure triggered by others’ suffering; see also Cikara, Botvinick, & Fiske, 2011). Finally, using transcranial magnetic stimulation to assess the motor

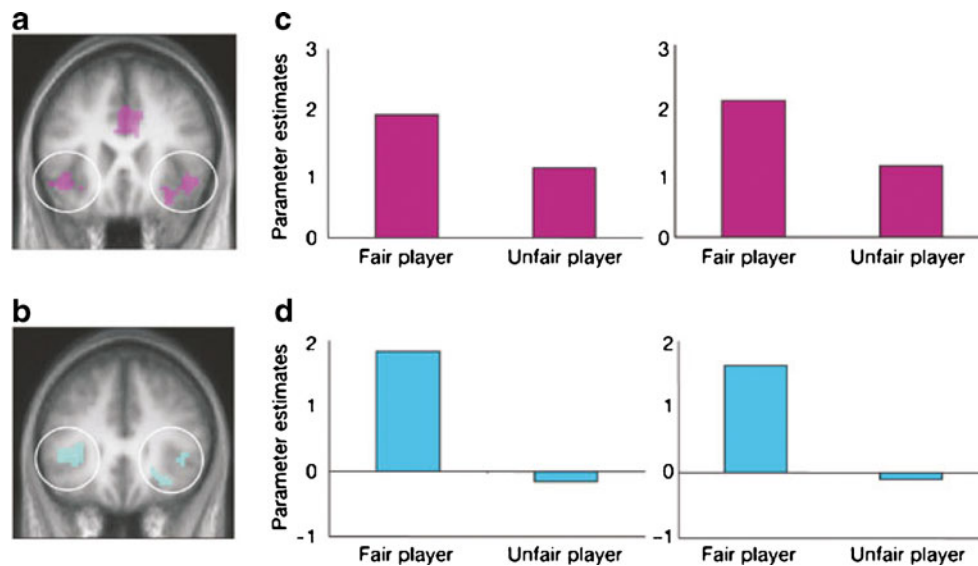


Fig. 5 Pain-sensitive activation networks to the sight of fair and unfair players in pain. **a, b** Conjunction analysis between pain–no pain in the context of self and the fair condition at $p < .001$ for women (pink, panel **a**) and men (blue, panel **b**). Increased pain-related activation for women in the anterior cingulate cortex, the left and right FI, and the left and right brainstem. **c, d** Average activation (parameter estimates) in peak voxels

of the left and right FI (left and right panels, respectively) for the painful–nonpainful trials in fair and unfair conditions for women (panel **c**) and men (panel **d**). Reprinted from “Empathic Neural Responses Are Modulated by the Perceived Fairness of Others,” by T. Singer et al., 2006, *Nature*, 439, 466–469. Reprinted with permission

evoked potentials (MEPs) as a measure of pain resonance, one report showed that decreased MEPs occurred only when others in pain belonged to the in-group (Avenanti, Sirigu, & Aglioti, 2010).

Individual personal contexts

Not only the external cues triggering disambiguation of information about empathy for pain, but also the learning through personal experiences involving exposure to contextual situations of pain should modulate the empathy activation in an adaptive direction.

For instance, two studies investigated how physicians react to the perception of others' pain. One study compared the neuro-hemodynamic response in a group of physicians and a group of controls while they viewed videos depicting face, hands, and feet being pricked by a needle (painful situations) or being touched by a Q-tip (nonpainful situations) (Cheng et al., 2007). The activation of the pain matrix in controls *but not* in physicians occurred when painful situations were watched, relative to the nonpainful (Fig. 6). A similar study with physicians was later replicated with an ERPs study (Decety, Yang, & Cheng, 2010). The results showed, in controls, an early N110 differentiation between pain and no pain, reflecting negative arousal, in the frontal cortex, as well as late P300 in the centro-parietal regions. In contrast, no such early ERP response was detected in the physicians. This evidence indicates that affect regulation in physicians has very early effects, inhibiting the bottom-up processing of negative arousal arising from the perception of painful stimuli and, thus, may

have beneficial consequences, such as freeing the cognitive resources necessary for providing assistance and expressing empathic concern.

The situated nature of empathy

All of the reviewed studies suggest that empathy for pain is not a modular or context-invariant phenomenon but that several contextual factors influence the affective, sensorimotor, and cognitive processing of the pain matrix. The neural networks of empathy for pain do not merely resonate with others' physical condition but are a contextually embedded process. This process would reflect an empathic flexibility that allows people to adapt their reaction to the current situational demands (Bernhardt & Singer, 2012).

Most of the reports reviewed here (except some studies described in [The contextual reality of the stimuli](#) and the [Individual personal contexts](#) sections) detail the specific *social* influence of SCNM on empathy. Nevertheless, frontotemporal engagement of contextual modulation is observed during other social domains or even nonsocial cognition domains, suggesting a general processing for situatedness.

How does the brain integrate the contextual information within pain activation? Although contextual effects have been proposed as inherent in social phenomena (Adolphs, 2009) and it is well-known that brain regions involved in empathy are modulated in their activation by social context (Hein & Singer, 2008; Singer & Lamm, 2009), current models of empathy for pain integration of contextual information are scarce. On the basis of the SCNM (Ibanez & Manes, 2012),

we propose that the contextual influence on the empathy process depends on a frontoinsula-temporal network.

The social context network model (SCNM)

In social situations, people use common sense and implicit associative learning derived from previous experience to update the contextual frames to predict the meaning of the social targets that are most likely to appear in a specific scene, using information about their relationships. A cortical network (SCNM; Fig. 7) that mediates the processing of such contextual associations in social cognition settings involving the regions in frontal, insular, and temporal areas has been proposed (Ibanez & Manes, 2012). The von Economo neurons (VENs) in the frontoinsula cortex are present in great apes and humans, but not in other primates, and they are more numerous in humans than in apes (Allman et al., 2010). VEN-containing regions connect with the frontal pole and with other parts of the frontal cortex, insular cortex, and temporal areas (Allman et al., 2010; Allman, Tetreault, Hakeem, Manaye, et al., 2011; Allman, Tetreault, Hakeem, & Park, 2011). Moreover, these neurons possess a distinctive anatomical feature, large axons that facilitate the connection between

Social Context Network Model

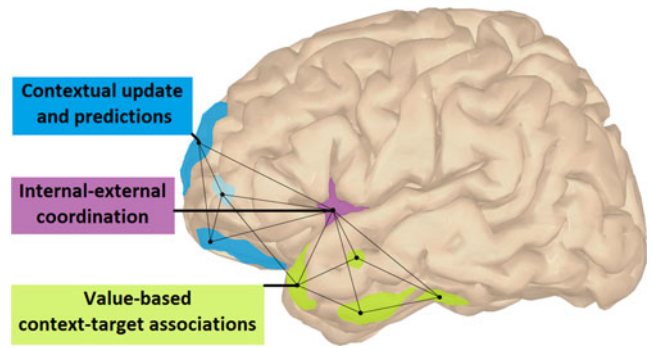


Fig. 7 The context network model (CNM). The CNM proposes that there are three subsystems engaged in updating context information and prediction making (frontal), internal-external information coordination (insula), and value-based target-context associations (temporal sites). Adapted from “Contextual Social Cognition and the Behavioral Variant of Frontotemporal Dementia,” by A. Ibanez & F. Manes, 2012, *Neurology*, 78, 1354–1362. Reprinted with permission

the frontoinsula cortex and the other cortical regions (Allman, Watson, Tetreault, & Hakeem, 2005). Thus, frontoinsula-temporal regions recruited in the SCNM are strongly interconnected. Various frontal areas up-date the ongoing contextual information in relation to episodic memory and target-context associations (as indexed by different temporal

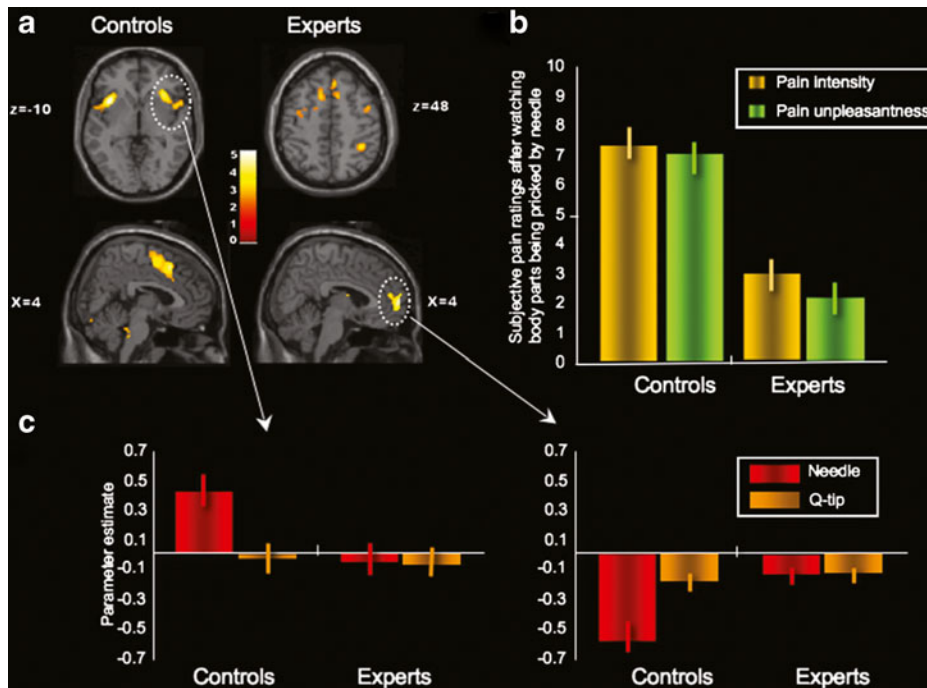


Fig. 6 Differential neural activations between experts and controls when watching body parts being pricked by an acupuncture needle. **a** Subjects from the control group activated the bilateral insula, periaqueductal gray, anterior cingulate cortex, and supplementary motor area, whereas subjects from the expert group activated the right inferior parietal lobule and medial prefrontal gyrus. **b** As compared with the expert group, subjects from the control group scored significantly higher on pain intensity and unpleasantness ratings. **c** Parameter estimate graphs show signal change

in the insula and medial prefrontal cortex for each condition in each group. When watching acupuncture procedures, a stronger activation was detected in the anterior insula in the control group, whereas the experts showed a stronger activation in the medial prefrontal cortex. When watching a Q-tip, there was no such double dissociation. Reprinted from “Expertise Modulates the Perception of Pain in Others,” by Y. Cheng et al., 2007, *Current Biology*, 17, 1708–1713. Reprinted with permission

sites). The insula plays a crucial role in the contextual modulation of empathy because it allows for the integration of internal states, feelings, and motivations with the information about the specific situation. Moreover, the anterior part of the insula, together with the ACC, is the key node of the salience network that plays a critical role in perceiving important context-dependent information and generates the appropriate behavioral response to salient events (Menon & Uddin, 2010; Seeley, Zhou, & Kim, 2012).

Thus, the salience network converges with the SCNM, highlighting the influence of large-scale functional connections for the integration of contextual information and the social cognition process.

The role of the frontal lobe in contextual update and prediction

Frontal regions (orbital, prefrontal, and lateral portions) are engaged in the prediction of the meaning of actions based on the integration of contextual information with the encoding and the retrieval of episodic learning (Barbas, Zikopoulos, & Timbie, 2011; Lang et al., 2009; Watanabe & Sakagami, 2007). Prefrontal neurons have shown rapid adaptation to context-dependent information with behavioral significance (Kusunoki, Sigala, Gaffan, & Duncan, 2009; Sigala, Kusunoki, Nimmo-Smith, Gaffan, & Duncan, 2008; Watanabe & Sakagami, 2007). The contextual update of visual targets activates the superior orbital sulcus (SOS) (Bar, 2004). The SOS plays a role in the generation of predictions via the update of associative activation, which is triggered by the context (Bar, 2009). On the other hand, patients with a frontal lobe stroke fail to identify how context alters the social meaning and ignore the incongruity of context (Mesulam, 2002).

Context–target associations in the temporal lobe

The hippocampus, amygdala, and related temporal sites (e.g., the perirhinal cortex) index the target–context associative processing (Greene, Gross, Elsinger, & Rao, 2006; Lang et al., 2009; Langston & Wood, 2010) and linked mechanisms, such as extinction (Bouton, Westbrook, Corcoran, & Maren, 2006), environment representation (Bilkey, 2007), and aversive associative learning (Buchel, Dolan, Armony, & Friston, 1999). In humans, the parahippocampal cortex receives polysensory and somatosensory information required for mediating global contextual associations (Bar, 2004). The medial temporal lobes recruit contextual associations to fit the incoming information of the frontal regions (Mayes & Roberts, 2001). In several psychiatric conditions, frontotemporal interaction seems to affect the context–target associations of the emotional relevant information (Millan et al., 2012), and more specifically, when a contextual situation must be inferred during empathy tasks, the

frontotemporal sites (the mPFC and temporal regions) are usually recruited (Bernhardt & Singer, 2012).

The insula: balance among internal and external milieus

The insula is a major cortical brain area involved in different cognitive, affective, and regulatory functions, including interoceptive awareness, emotional responses, and empathy (Couto, Salles, et al., 2013; Ibanez, Gleichgerrcht, & Manes, 2010; Touroutoglou, Hollenbeck, Dickerson, & Feldman Barrett, 2012). The insula integrates contextual information with specific feelings to produce a general evaluation (Singer et al., 2009). The insula acts as an interoceptive “body marker” of our experiences of empathy for pain (e.g., empathic concern and pain avoidance), and AI may constitute the main neural hub of empathy process (Singer, Seymour, et al., 2004).

Nevertheless, the insula seems to play a general role (not restricted to empathy processing) in the integration of the internal and external milieus (Craig, 2009; Ibanez, Gleichgerrcht, & Manes, 2010; Singer et al., 2009). Seeley (Seeley et al., 2007) used rs-fMRI to demonstrate that both the AI and dACC are the key nodes of an independent brain network, the “salience network,” which facilitates the detection of important contextual stimuli and segregates the most relevant stimuli among the internal states and the external stimuli and guides behavior. These regions coactivate in response to varied forms of salience, including the emotional dimension of pain (Peyron et al., 2000) empathy for pain (Singer, Seymour, et al., 2004), faces of loved ones (Bartels & Zeki, 2004) or allies (Singer, Kiebel, Winston, Dolan, & Frith, 2004), and social rejection (Eisenberger, Lieberman, & Williams, 2003). Thus, the salience network, with the insula as its integral hub, facilitates target brain regions generating the appropriate behavioral responses to significant stimuli (Lavin et al., 2013; Menon & Uddin, 2010; Seeley et al., 2007; Seeley et al., 2012).

Moreover, the integrating role of the insula during social cognition tasks may be dependent on its frontotemporal connections (Couto, Manes, et al., 2013; Couto, Seden, et al., 2013). Frontal and temporal regions are strongly connected with the insula, especially the regions (ACC/MCC, OFC, amygdala, and striatum) regulating context-dependent behaviors (Bernhardt & Singer, 2012). Thus, the contextual modulation of the frontotemporal regions should influence and, at the same time, be influenced by the insula.

Thus, the SCNM would modulate and influence the pain matrix depending on the specificity of the situation and the saliency of the event, allowing a very complex pool of empathic responses in each situation. At the same time, the SCNM affects the different affective, sensorimotor, and cognitive components of the empathic process at bottom-up and top-down stages. Thus, the interaction of both networks (empathy for pain matrix–SCNM) would allow the prediction of

the situation's social meaning on the basis of an update of previous context–target associations and their motivational relevance for the observer.

Empathy and the SCNM in neuropsychiatric conditions

The majority of neuropsychiatric conditions have deficits in social cognition domains and/or abnormal activation of the social brain areas (Ibanez, Aguado, et al., 2013; Kennedy & Adolphs, 2012; Millan et al., 2012). Some conditions share impairments in both the contextual integration and empathic processes. These conditions detailing the convergent impairments of contextual appraisal and empathic process are presented below.

Empathy and context in AS

AS is a pervasive developmental disorder characterized by severe and sustained impairments in social interaction (particularly empathy; Baron-Cohen, 2009) and by the development of restricted repetitive patterns of behavior, interests, and activities. Adults with AS, as well as adults with autism spectrum disorders (ASDs), exhibit deficits in multiple social cognition domains. Specifically, it has been proposed that AS patients have difficulty in identifying the emotions and thoughts of others and responding with an appropriate emotion (Baron-Cohen, 2002). Although reduced empathy is considered a core feature of AS (Baron-Cohen & Wheelwright, 2004; Dziobek et al., 2008), the majority of studies have focused on either the cognitive or the emotional component alone and have relied on self-report questionnaires (Baron-Cohen & Wheelwright, 2004; Rogers, Dziobek, Hassenstab, Wolf, & Convit, 2007; Shamay-Tsoory, Tomer, Yaniv, & Aharon-Peretz, 2002), which likely present limited ecological validity (Dziobek et al., 2008) and require abilities such as abstract thinking and introspection.

Regarding the assessment of contextual clues during empathy tasks, only one behavioral study has assessed this issue (Baez et al., 2012). AS adults were tested with multiple social cognition tasks (including measures of empathy) with differing degrees of contextual influence. AS adults presented with a pattern of social cognition deficits characterized by a decreased ability to implicitly encode and integrate contextual information to gain access to the social meaning. Nevertheless, when social information was explicitly presented or the situation could be navigated with abstract rules, their performance improved. These findings confirm previous reports that suggested that AS adults may use abstract rules to compensate for their impairments in social cognition (Hayashi, Kato, Igarashi, & Kashima, 2008; Soulieres, Dawson, Gernsbacher, & Mottron, 2011). In addition, a context-dependent measure of empathy (EPT) triggered the contextual influences in the

identification of intentional and accidental harms. AS patients showed abnormal empathic concern, punishment, and discomfort ratings for intentional pain situations (when the intention to hurt needed to be inferred from the contextual information). Consistent with previous findings (Dziobek et al., 2008; Klin, 2000; Rogers et al., 2007; Zalla, Sav, Stopin, Ahade, & Leboyer, 2009), this study indicates that AS individuals have difficulty with inferring the intentionality of actions from the scenarios in which explicit contextual information is not available.

At the neural level, there is increasing evidence suggesting that people with ASD have anatomical differences in specific limbic tracts that connect temporal and orbitofrontal limbic regions (Pugliese et al., 2009). The ACC and its connections with the pain matrix (Lavin et al., 2013) are significantly less activated during social tasks in ASD (Di Martino et al., 2009; Thakkar et al., 2008). Moreover, AS adults present with smaller insula volumes (Kosaka et al., 2010) and insufficient activation of the right insula during an empathizing task in an fMRI study (Baron-Cohen et al., 1999). Additionally, adults with ASD show abnormal fronto-insular-temporal activation during social cognition tasks (Castelli, Frith, Happe, & Frith, 2002; Pelphrey, Adolphs, & Morris, 2004; Silani et al., 2008). Finally, in ASD subjects, fronto-temporo-parietal brain regions serving to associate the contextual information are atypically activated when a social context is presented at the time of encoding (Greimel et al., 2012). Together, these findings suggest that the SCNM could be related to the peculiar deficits of AS and seem to be associated with impairments in the capacity to *implicitly* integrate action intentions with contextual cues to access the social meaning, not only in empathy tasks, but also among different social skills (Baez et al., 2012). Nevertheless, both hypotheses (the *implicitness* and the *general impairment* of contextual social cognition) require further research and direct testing of contextual manipulations and frontotemporal-activation-specific measurements.

Empathy and context in schizophrenia

SCZ is among the most disabling mental illnesses and frequently causes impaired social functioning (Brissos, Molodynski, Dias, & Figueira, 2011). In patients with SCZ, several studies have shown deficits in multiple social cognition domains, including empathy (for a meta-analysis, see Achim, Ouellet, Roy, & Jackson, 2011). However, most of these findings were obtained using tasks that do not manipulate contextual influences.

At a behavioral level, one study evaluated the performance of SCZ patients and patients with bipolar disorders in social cognition tasks, which incorporated different levels of contextual dependence and real-life involvement (Baez et al., 2013). The results demonstrated that both patient groups exhibited deficits in social cognition tasks with greater context sensitivity

and real-life involvement. These findings are consistent with recent reports of social context processing deficits in SCZ (Huang, Chan, Lu, & Tong, 2009; Monkul et al., 2007; Penn, Ritchie, Francis, Combs, & Martin, 2002). Patients did not differ from controls in tasks involving explicit knowledge. A previously described ecological task of empathy for pain (EPT) was also assessed. SCZ patients exhibited difficulties in comprehending the situations, suggesting deficits in the ability to distinguish neutral and accidental situations from intentional pain situations in settings with contextual information provided (see also Montag, Heinz, Kunz, & Gallinat, 2007; Villatte, Monestes, McHugh, Freixa i Baque, & Loas, 2010). These results are also consistent with those in studies of SCZ patients who reflect double impairments in contextual appraisal and emotion inference (Champagne-Lavau, Charest, Anselmo, Rodriguez, & Blouin, 2012; Huang et al., 2009; Ibanez, Riveros, et al., 2012; Monkul et al., 2007; Riveros et al., 2010).

Consistent with the proposal of a wide SCZ impairment on contextual modulation, recent reports suggest a general and multilevel deficit in contextual integration of information, from the more basic process (e.g., visual perception; Dakin, Carlin, & Hemsley, 2005; Javitt, Shelley, Silipo, & Lieberman, 2000; Uhlhaas, Silverstein, Phillips, & Lovell, 2004) to high-level cognition (e.g., speech and social cognition; Amoroso, Cardona, Melloni, Sedeño, & Ibanez, 2012; Chung et al., 2010; Green, Waldron, Simpson, & Coltheart, 2008; Ibanez, Riveros, et al., 2011; Penn et al., 2002). In SCZ, basic context-dependent perception (especially during visual paradigms) seems to be systematically affected, suggesting that impairments in contextual appraisal of empathy would be a part of a more extended contextual impairment.

At the structural and functional neural levels, the most affected brain areas in SCZ are the temporal and frontal regions. Systematic meta-analysis of SCZ volumetric studies (Shepherd, Laurens, Matheson, Carr, & Green, 2012) reveals gray matter reductions of frontal, temporal, and insular regions. Regarding the neural correlates of empathy, SCZ patients showed a significant impairment in empathic behavior, accompanied by dysfunctional activation in regions known to be related to empathy and contextual integration, such as the insula, amygdala, and ACC (Derntl et al., 2012; Fakra, Salgado-Pineda, Delaveau, Hariri, & Blin, 2008; Gur et al., 2007; Habel et al., 2010). More specifically, impaired empathy in SCZ underlies an abnormal fronto-insular-temporal network (Benedetti et al., 2009; Lee et al., 2010).

Disentangling the contextual deficits from basic empathic processes provides important insights into the cognitive profile of SCZ. In these patients, deficits in context processing may be a core deficit that underlies perceptual, cognitive, and social cognition impairments, including empathy (Chung & Barch, 2011).

Empathy and context in the behavioral variant of frontotemporal dementia

The bvFTD is a neurodegenerative disease mostly characterized by progressive changes in personality and social cognition, including a loss of empathy, disinhibition, impaired social awareness, and loss of insight (Mendez & Perryman, 2002; Neary et al., 1998). Patients with the bvFTD present with deficits in empathy processing (Eslinger et al., 2011; Fernandez-Duque, Hodges, Baird, & Black, 2010; Lough et al., 2006; Mendez & Perryman, 2003; Perry et al., 2001; Piguet, Hornberger, Mioshi, & Hodges, 2011; Rankin et al., 2006; Rankin, Kramer, & Miller, 2005) and several impaired domains of social cognition, such as facial expression (Lough et al., 2006), decision making (Gleichgerricht, Ibanez, Roca, Torralva, & Manes, 2010; Manes et al., 2011), figurative language (e.g., sarcasm, Rankin et al., 2009); ToM, (Torralva et al., 2007; Torralva, Roca, Gleichgerricht, Bekinschtein, & Manes, 2009), and interpersonal norms (Rankin, Kramer, Mychack, & Miller, 2003; Sollberger et al., 2009). These results lead to the hypothesis that the bvFTD presents an intrinsic affectation of the SCNM that results in the inability to incorporate context into the control of social behavior (Ibanez & Manes, 2012).

At the neural level, disruption of the orbitofrontal–amygdala circuit and other frontotemporal networks are thought to be responsible for the main bvFTD symptoms (Hodges, 2001). The right OFC regulates behavior with a predominantly right-sided network involving the insula and the striatum (Viskontas, Possin, & Miller, 2007). The initial symptoms of the bvFTD reflect the involvement of OFC and the disruption of the rostral limbic system, which involves the insula, the ACC, the striatum, the amygdala, and the medial frontal lobes (Boccardi et al., 2005; Viskontas et al., 2007), followed by the temporal pole, the dorsolateral frontal cortex, and the basal ganglia. In addition, studies using voxel-based morphometry have shown that bvFTD patients have a crucial gray matter loss in the AI and other frontal areas (Williams, Nestor, & Hodges, 2005). Interestingly, the specific network of the ACC and orbital fronto-insular regions seems to be involved in processing the emotional salience of stimuli (Seeley et al., 2007). This evidence likely suggests that one aspect of the decreased ability to attend to salient, socially significant cues may depend on the connectivity in a right fronto-insular intrinsic network that is selectively targeted by this disease (Seeley, Crawford, Zhou, Miller, & Greicius, 2009; Shany-Ur et al., 2012). Together, all these findings suggest that the specific pattern of social cognition impairment in the bvFTD can be understood as general deficits in the integration of the social context triggered by an abnormal fronto-insular-temporal network (Ibanez & Manes, 2012; Seeley et al., 2012).

Plausibility and relevance of the SCNM in AS, SCZ, and the bvFTD

Above, we have briefly summarized recent preliminary evidence of contextual impairments during empathy tasks in AS, SCZ, and the bvFTD, which suggests an overlapping and partial dissociated pattern of impairment among these disorders. These disorders involve abnormal structure, activity, and connectivity at the main hubs of the SCNM. Although highly speculative, partially shared empathic and contextual integration deficits in AS, SCZ, and the bvFTD may refer to abnormal brain connectivity among the areas predicting the social meaning of empathy-triggering situations through the update of experience-based learning of target–context associations.

Impairments in the *implicit* contextual appraisal of social cognition (including but not exclusively empathy) would be a core feature of AS. A pattern of social cognition deficits characterized by a decreased ability to implicitly encode and integrate contextual information to gain access to the social meaning has been identified in recent reports. Conversely, in AS, a better behavioral and typical neural response is observed in social cognition tasks with explicit abstract information.

In SCZ patients, ecological measures with context-processing requirements seem to be more sensitive than classical social cognition tasks. Nevertheless, contextual impairments in SCZ are observed in nonsocial domains, suggesting that the impairment in context-dependent empathy tasks represents only a subset of a more general affectation of contextual appraisal.

The bvFTD is a prototypical disorder in which contextual social behaviors are disrupted. Different sources of evidence suggest that the ability to integrate others' emotions and intentions within a specific social context is a core bvFTD impairment underlying empathy and social cognition deficits.

Taken together, these findings raise three main questions. (1) Are the empathy deficits described in AS caused by impairments of the *implicit* encoding and the integration of contextual information to access social meaning (Baez et al., 2012)? (2) Is there a general (not restricted to social cognition or empathy) impairment of contextual integration in SCZ (Baez et al., 2013)? (3) Does the bvFTD involve a specific deficit of contextual integration of social information (Ibanez & Manes, 2012)? These outstanding questions cannot be answered with current evidence, but they open a new line of research, whose aim is to help disentangle the interaction among empathy and contextual processes and the differences among these disorders.

Contextual influences in cognitive neuroscience are usually ignored (Bar, 2004; Maren, Phan, & Liberzon, 2013). For modular theories of social cognition (e.g., Chiao & Immordino-Yang, 2013; Cosmides & Tooby, 1997), the mind is composed of a set of domain-specific and functionally

specialized modules. Thus, theory of mind was conceptualized as having modular properties (Apperly, Samson, & Humphreys, 2005; Baron-Cohen, Leslie, & Frith, 1985; Leslie, 1992) even when not presenting all modular features (Ibanez, Huepe, et al., 2013; Stone & Gerrans, 2006). In the case of empathy, similar explanations in terms of domain specificity (Gu et al., 2010) or single explanatory mechanisms such as the mirror system mechanism (e.g., Iacoboni, 2009) seem to be inadequate or insufficient for understanding the flexible and adaptive empathic responses.

Moreover, a contextual approach to empathy and its relationship with SCNM would provide more sensitive measures of cognitive impairments in the conditions described above. In these disorders, empathy is mostly assessed through self-reporting or experimental designs without contextual modulations. It is also important to promote the use of tasks involving real-life social scenarios, because this type of “ecological” measure is a context-sensitive tool and should be applied in neuropsychiatry (Burgess, Alderman, Volle, Benoit, & Gilbert, 2009; Ibanez & Manes, 2012; Torralva, Roca, Gleichgerricht, Bekinschtein, & Manes, 2009).

On the other hand, the traditional empathic skills interventions for individuals with neuropsychiatric conditions are based on learning explicit rules to build and foster relationships with others. However, social skills acquired during those interventions fail to generalize to situations outside of the treatment setting. Thus, incorporating naturalistic environments and the implicit learning of contextual clues into the treatment plan may help individuals with neuropsychiatric conditions to generalize the learned empathic skills. Although the implementation would be challenging, intervention programs should be based on teaching implicit rules for interpreting unpredictable social contexts.

Concluding remarks

Social context modulation seems to be involved in empathy for pain. In that sense, empathy can be better understood as a complex contextual phenomenon related to different processes and different neuronal networks (Kennedy & Adolphs, 2012). Empathy processes should not be reduced to a single or unique structural activation (e.g., the insula or ACC) but, on the contrary, should include a complex and context-related network. The SCNM provides an explanation for flexible empathic processes. Here, the frontal regions would update and predict the social meaning by recruiting previous experiences stored in temporal regions, and the insular “mediator effect” would index balance among the saliency of external information and the intrinsic relevance for the internal and motivational states. Empathy should involve the coactivation of the SCNM, depending on the ambiguity of the information

provided in the social scenarios. Thus, the interaction of empathic processes with contextual information would recruit an extended and distributed network that would be further investigated in normal and neuropsychiatric conditions.

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