# How Would *You* Feel versus How Do You Think *She* Would Feel? A Neuroimaging Study of Perspective-Taking with Social Emotions

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## Abstract

■ Perspective-taking is a complex cognitive process involved in social cognition. This positron emission tomography (PET) study investigated by means of a factorial design the interaction between the emotional and the perspective factors. Participants were asked to adopt either their own (first person) perspective or the (third person) perspective of their mothers in response to situations involving social emotions or to neutral situations. The main effect of third-person versus first-person perspective resulted in hemodynamic increase in the medial part of the superior frontal gyrus, the left superior temporal sulcus, the left temporal pole, the posterior cingulate gyrus, and the right inferior parietal lobe. A cluster in the postcentral gyrus was detected in the reverse comparison. The amygdala was selectively activated when subjects were processing social emotions, both related to self and other. Interaction effects were identified in the left temporal pole and in the right postcentral gyrus. These results support our prediction that the frontopolar, the somatosensory cortex, and the right inferior parietal lobe are crucial in the process of self/other distinction. In addition, this study provides important building blocks in our understanding of social emotion processing and human empathy. ■

## INTRODUCTION

What does it mean to take another person's perspective? If we put ourselves in someone else's place, do we really feel what she feels? Does having a more accurate perception of another person's state of mind make us more sympathetic to his plight? These questions are often addressed in social psychology using overlapping concepts like perspective taking and empathy. Adopting another person's perspective involves more than simply focusing our attention on the other. It involves imagining how that person is affected by his or her situation without confusion between the feelings experienced by the self versus feelings experienced by the other person (Davis, 1996).

A number of perspective-taking models in social psychology assert that the social construction of meaning derives from one's own implicit theories about what the other knows, feels, thinks, and believes (Kraus & Fussell, 1996). Thus, understanding the states of mind of another person requires taking into account their perspective in visual, conceptual, and affective domains. Gilovich, Medvec, and Savitsky (2000) proposed the "anchoring (*in the self-perspective*) and adjustment hypothesis" to explain the egocentric bias when assessing another's state of mind, as evidenced in numerous social psychological studies (e.g., Nickerson, 1999; Fenigstein & Abrams, 1993; Markus, Moreland, & Smith, 1985). Such a hypothesis is similar to the simulation theory posited by developmental psychologists (e.g., Taylor, Esbensen, & Bennett, 1994; Harris, 1989) and philosophers of mind (e.g., Goldman, 1992; Gordon, 1986) to explain the human ability to read the other's mind (theory of mind [ToM]). The simulation theory maintains that human beings are able to use the psychological resources responsible for their own behavior to simulate the behavior of others by projecting themselves into the situation encountered by the other (and thus inferring the psychological causes of the other's behavior), typically by making decisions within a "pretend" context. An interesting aspect to emphasize is that both hypotheses suggest a major influence of the self-perspective in the construction of the other's perspective representation. Consistent with such a view, Vorauer and Ross (1999) have proposed that errors in assessing another's perspective are rooted in a failure to suppress one's self.

In cognitive neuroscience, the model of self-perspective as the default mode of our mental functioning may account for the phenomenon that similar brain areas and computational processing have been involved during the execution of action, mental representation of one's own action, and observation of another's action (Grezes & Decety, 2001). These results also support the common coding model of perception and action.

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According to this model, perception and action share common cognitive and neural codes, and perception of a given behavior in another individual automatically activates one's own representations of that behavior (Viviani, 2002; Prinz, 1997).

But sharedness does not mean identicality; otherwise, representations of self and others would completely overlap and lead to some confusion. Indeed, if one uses the same mental/neural resources for representing her own intentions, beliefs, and desires and those of others, then it is crucial to possess a mechanism to distinguish between the self and the other (Decety & Sommerville, 2003).

Previous neuroimaging studies by our group have directly tackled this question by instructing individuals to adopt their own perspective (first person) or the perspective of another person (third person) in the motor domain (Ruby & Decety, 2001) and in the conceptual domain (Ruby & Decety, 2003). Both studies demonstrated specific involvement of the right inferior parietal lobe and frontopolar cortex when the third-person perspective was compared to the first-person perspective, whereas the somatosensory cortex was detected in the reverse comparison. These regions have been interpreted to participate in the process of self/other distinction irrespective of the domain concerned (motor and conceptual).

The aim of this study was to test whether we could extend our results to the emotional domain, contrasting the hemodynamic response to first- and third-person perspective taking in a social–emotional context. This is an important issue because empathy stems from the process of the emotional perspective-taking process and the issue of self/other distinction is an essential component for experiencing empathy. Empathy researchers (e.g., Batson, 1987; Wispé, 1986) as well as psychotherapists (e.g., Rogers, 1975; Reik, 1949) make it clear that a merging or confusion of self and other is not the goal of empathy. Hence, an essential part of empathy is to recognize the other person as like the self while maintaining a clear separation between self and other (Jackson & Decety, 2004; Decety & Chaminade, 2003; Batson, Early, & Salvarani, 1997; Batson, Sager, et al., 1997; Ickes, 1997). This suggests that there is an important role for an inhibitory/regulatory mechanism in the neural machinery of empathy that helps to maintain this gap.

Dixon and Moore (1990) have suggested that perspective taking involves two components: (1) the information effect, which is related to the assessment of what the interlocutor knows and (2) the weighting effect, which expresses the necessity to also assess how the interlocutor will weight different information to make a decision.

In a previous experiment we focused on the "information effect" (Ruby & Decety, 2003); in this study we added the "weighting effect" component. Participants were asked, according to the experimental conditions, to adopt either their own perspective (P1) or the perspective of their mother (P3) in response to neutral (N) and emotional (E) verbal, visually presented questions (Figure 1). In the neutral conditions, participants, who were selected as medical students, had to give an opinion about the truthfulness of assertions in the medical domain. In the emotional conditions, they were requested to report the reaction that would arise in real-life situations likely to induce social emotions. We predicted that the main effect of third-person perspective versus first-person perspective (P3–P1) would result in the activation of the right inferior parietal lobe, the frontopolar cortex, and other regions known to be involved in "Theory of Mind" (ToM) tasks that were found in similar experiments looking at perspective taking (Ruby & Decety, 2001, 2003). In the reverse comparison (P1–P3), we expected activation in the postcentral gyrus.

Another goal of this study was to investigate the effect of the emotional factor on the activity in the regions involved in perspective taking. Emotions are known to influence reasoning (e.g., Goel et al., 2001; Houdé et al., 2001; Bechara, Damasio, & Damasio, 2000; Bush, Luu, & Posner, 2000; Damasio, 1994), and some of the regions found in perspective taking have also been shown to be involved in emotional processing. For this reason, interaction effects are expected, especially in the somatosensory cortex, which has been shown to be involved in emotional recognition of facial expressions, and in self-generated emotions (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000; Damasio et al., 2000). Interaction effects were also predicted in the temporal poles, which are part of the common network involved in emotion processing irrespective of the triggering sensory modality (Royet et al., 2000).

## RESULTS

### Behavioral Results

*Response Type*

In the PN conditions, subjects gave on average 28.1 (range 19–36) distinct answers between PN1 and PN3 for the 60 sentences presented. Fifty percent of the sentences presented were selected as likely to induce different responses depending on the perspective. Therefore, the performances of the subjects are a good

| | | Perspective | |
|---|---|---|---|
| | | 1st person | 3rd person |
| Emotion | – | PN1 | PN3 |
| | + | PE1 | PE3 |

**Figure 1.** The 2 × 2 factorial design used in the experiment.

indicator that they succeeded in doing the task. These results reproduce those obtained in a previous study in which subjects were presented with the same stimuli but had to take the perspective of a layperson representative of the population not educated in health sciences (Ruby & Decety, 2003). The reproducibility of the results indicates firstly that they are robust, and secondly that the process of perspective taking is independent of the target from whom one takes the perspective.

In the PE conditions, subjects gave on average 25.5 (range 18–33) distinct answers in PE1 and PE3 for the 60 phrases presented in the three repetitions. This result is comparable to the one obtained in the PN conditions, which allows statistical comparison of brain imaging data between PE and PN.

### *Reaction Time*

A two-way analysis of variance showed no significant difference in reaction times (RTs) between P1 ($X$ = 3744 msec) and P3 ($X$ = 3826 msec) conditions, $F(1,9) = 1.17$. This result replicates the equivalence in reaction time found in a previous study between PN1 and PN3 conditions (Ruby & Decety, 2003). A significant RT difference was found between PE ($X$ = 3992 msec) and PN ($X$ = 3578 msec) conditions, $F(1,9) = 24.4$, $p < .0001$. However, this difference is small (416 msec) compared to the mean reaction time. Hence, even if we cannot exclude it, it seems unlikely that hemodynamic changes between PE and PN conditions arise from a difference in task difficulty.

## Neuroimaging Results

### *Main Effect of Third-Person versus First-Person Perspective Irrespective of the Content of the Stimuli [(PN3 + PE3) – (PN1 + PE1)]*

The main effect of third- versus first-person perspective revealed activation in frontal, parietal, and temporal lobes (Table 1, Figure 2). In the frontal lobe, numerous clusters were detected all along the superior frontal gyrus in its medial part. In the parietal lobe, a cluster was detected in the right angular gyrus and in the posterior cingulate gyrus. In the temporal lobe, activations were found only in the left hemisphere in the temporal pole and in the superior temporal sulcus at the temporoparieto-occipital junction.

### *Main Effect of First-Person versus Third-Person Perspective Irrespective of the Content of the Stimuli [(PN1 + PE1) – (PN3 + PE3)]*

The main effect of first- versus third-person perspective revealed activation in the postcentral gyrus in the right hemisphere ($p < .001; x = 24, y = -30, z = 58; T = 3.44$).

**Table 1.** Cortical Areas Significantly Activated when Third-Person Perspective Conditions Are Compared to First-Person Perspective Conditions [(PN3 + PE3) – (PN1 + PE1)]

| | | Coordinates | | | |
|---|---|---|---|---|---|
| *Brain Region* | *L/R* | *x* | *y* | *z* | *T Value* |
| Gyrus rectus (BA 11) | L | −8 | 48 | −18 | 5.74 |
| Frontopolar gyrus (BA 10) | L | −8 | 64 | −8 | 5.24 |
| Frontopolar gyrus (BA 10) | R | 10 | 68 | 14 | 4.27 |
| Superior frontal gyrus (BA 8/9) | R | 4 | 50 | 40 | 4.08 |
| Superior frontal gyrus | L | −8 | 44 | 20 | 3.75 |
| Temporal pole (BA 21) | L | −58 | −4 | −32 | 5.10 |
| Temporoparieto-occipital junction | L | −58 | −58 | 28 | 4.14 |
| Posterior cingulate gyrus | R | 2 | −60 | 32 | 3.88 |
| Inferior parietal at the TP junction | R | 62 | −64 | 22 | 3.65 |
| Inferior parietal at the TP junction | R | 46 | −56 | 22 | 3.59 |

*x, y, z* refer to MNI coordinates. L = left hemisphere; R = right hemisphere. TP = tempoparietal BA refers to Brodmann's area. Focus of activation that survived correction for the whole brain volume are those exhibiting a $T > 5.02$.

### *Main Effect of Emotional versus Neutral Content of the Stimuli Irrespective of the Perspective [(PE1 + PE3) – (PN1 + PN3)]*

This main effect revealed activation in the regions known to be involved in emotional processing, namely, the temporal poles ($x = 54, y = 10, z = -34, T = 6.99$; $x = -44, y = 14, z = -32, T = 5.85$), the superior frontal gyrus ($x = 4, y = 54, z = 22, T = 6.23$), the posterior cingulate gyrus/precuneus ($x = 4, y = -60, z = 12, T = 4.71$), the postcentral gyrus ($x = 24, y = -30, z = 62; T = 4.76$), and the amygdala ($x = 26, y = -2, z = -24, T$=3.95, SVC (radius 20 mm), $p < .05$; $x = -26, y = 14, z = -32$, $T = 3.89$, SVC (radius 20 mm) $p = .05$) (Figure 3).

### *Interaction Effect between the Emotional and the Perspective Factors*

An interaction effect was found in the left temporal pole at the coordinate $x = -60, y = -2, z = -32$ ($T = 3.26$), in the contrast [(PE3 − PE1)–(PN3 − PN1)]. This region shows a greater involvement in the P3 conditions when it is an emotional context (Figure 4).

An interaction effect was also found in the postcentral gyrus in the right hemisphere at the coordinate $x = 18, y = -26, z = 60$ ($T$ = 2,52) in the interaction term [(PE1 − PE3)–(PN1 − PN3)]. This part of the somatosensory cortex shows a greater involvement in the P1 conditions when the context is emotional. It is more involved in first- versus third-person perspective taking but also in emotional versus neutral conditions. In

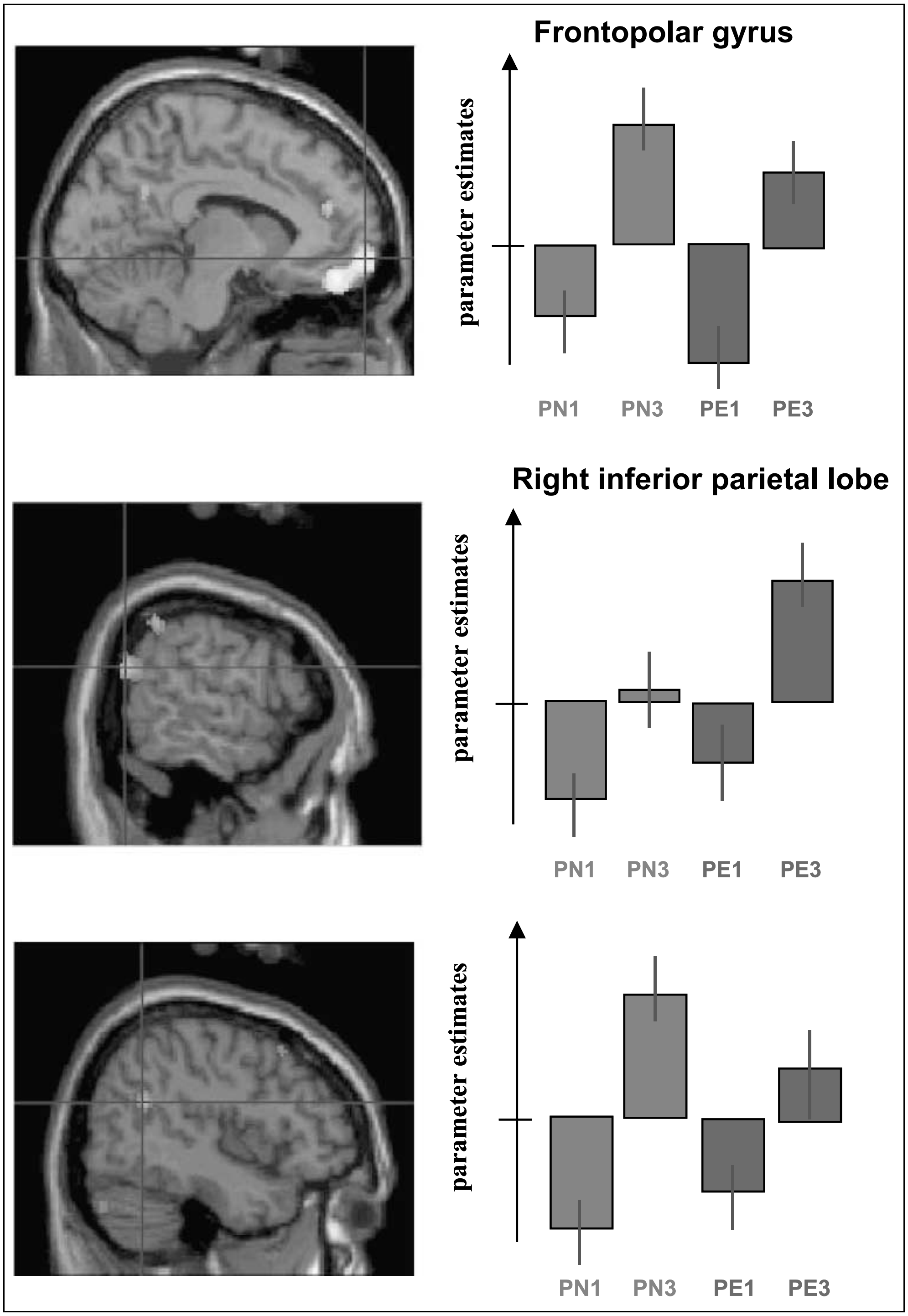



**Figure 2.** Cortical areas significantly activated when third-person perspective conditions are compared to first-person perspective conditions irrespective of the emotional content of the situations [(PN3 + PE3)−(PN1 + PE1)]. On the left, activated clusters superimposed on sagittal sections of a T1 image are shown at the coordinates ($x = -8, y = 64, z = -8$) on the top, ($x = 62, y = -64, z = 22$) in the middle, and ($x = 46, y = -56, z = 22$) at the bottom. On the right, histograms represent the mean and standard deviation of relative adjusted rCBF values in the four experimental conditions.

other words, this region is more activated in the PE1 condition when compared to any of the other conditions (Figure 5).

## DISCUSSION

This study used a 2 × 2 factorial design to contrast the neural correlates of first- and third-person conceptual perspective taking in an emotional context and to look for the interaction effect between perspective and emotion.

### Main Effect of Perspective

The main effect of third-person perspective as compared to first-person was significant activation in the right inferior parietal cortex and in the ventromedial prefrontal cortex including the frontopolar cortex and the gyrus

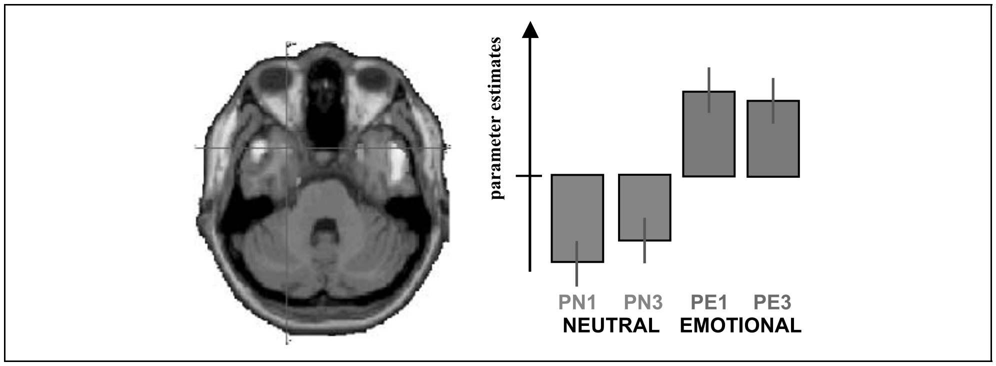



**Figure 3.** Activated clusters in both amygdala superimposed on a transverse section of the brain, and plots showing the relative adjusted rCBF values in the four experimental conditions.

rectus. The reverse comparison showed activation in the somatosensory cortex. Such results corroborate the findings of previous investigations of perspective-taking in the motor (Ruby & Decety, 2001) and conceptual domains (Ruby & Decety, 2003) and extend them to the emotional domain. The results of the present study indeed demonstrate that these regions are involved in the distinction between first- and third-person perspectives both in a neutral and in an emotional context, and that this occurs irrespective of who is the target of the perspective-taking process.

Evidence from clinical neuropsychology (Mesulam, 1981) as well as from psychopathology (Spence et al., 1997) has pointed out the importance of right inferior parietal lobe functional integrity for correct agency judgment (i.e., the awareness of being the initiator or source of a movement, action, or thought; Gallagher, 2000). Recently, Blanke, Ortigue, Landis, and Seeck (2002) have shown that direct cortical stimulation of this region induced out-of-body experience, that is, a third-person perspective visual experience of the self. In addition, functional neuroimaging studies in healthy subjects have provided converging results showing specific involvement of this region in the self/other distinction in reciprocal imitation (Decety et al., 2002) and in agency judgments (Blakemore, Oakley, & Frith, 2003; Farrer & Frith, 2002; Farrer, Franck, Frith, Decety, & Jeannerod, 2003). The present study shows the specific involvement of this region for third-person pers- pective taking both in neutral and emotional contexts (Figure 2). This supports the claim that this region plays a role in the process of attributing not only actions but also thoughts to other people (Decety & Sommerville, 2003; Meltzoff & Decety, 2003; Ruby & Decety, 2003).

In normal subjects, social–psychological studies have demonstrated that the egocentric perspective (i.e., first person) is the major factor biasing and preventing the correct assessment of another's perspective (Fenigstein & Abrams, 1993). Notably, it has been proposed that errors in such appraisal are rooted in a lack of suppression of the self-perspective (Vorauer & Ross, 1999; Hodges & Wegner, 1997). This assumption is also coherent with developmental research that shows that executive functions, and particularly inhibitory control, are crucial enabling factors for the development and the expression of ToM (Carlson & Moses, 2001; Perner & Lang, 1999). Converging evidence from neuropsychology (De Renzi, Cavalleri, & Facchini, 1996) and neuroscience (Brass, Zysset, & von Cramon, 2001; Fuster, 1989) points to the frontopolar cortex as being involved in inhibitory processing. Frontal damage may result in impaired perspective-taking ability (Price, Daffner, Stowe, & Mesulam, 1990) and a lack of cognitive flexibility (Eslinger, 1998). Interestingly, Anderson, Bechara, Damasio, Tranel, and Damasio (1999) reported the cases of two patients with early damage to the anterior prefrontal cortex (encompassing the frontopolar cortex but not the gyrus rectus) who, when tested on moral dilemmas, exhibited an excessively egocentric perspec-

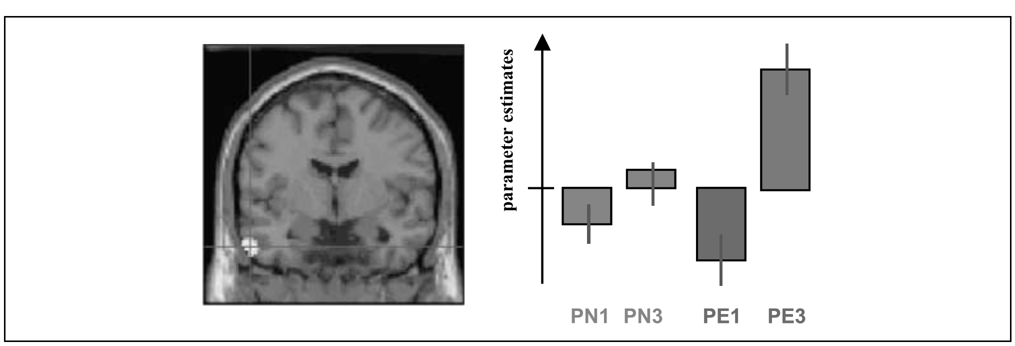
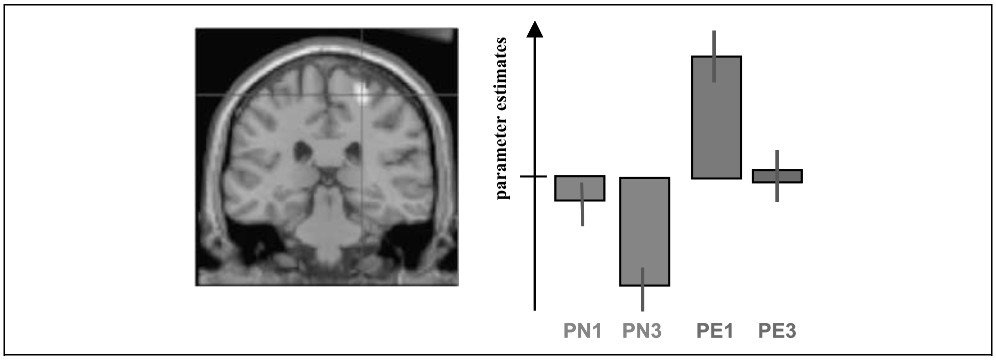



**Figure 4.** Activated cluster in the left temporal pole superimposed on a coronal section of the brain, and the relative adjusted rCBF values in the four experimental conditions.

**Figure 5.** Activated cluster in the right somatosensory cortex superimposed on a coronal section of the brain, and relative adjusted rCBF values in the four experimental conditions.




tive. The behavior of those patients reveals a lack of inhibition of self-perspective at the conceptual level. Hence, the study of Anderson et al. (1999) using a moral test provides evidence for the role of the frontopolar cortex in inhibition at the conceptual and social level. Our results support the hypothesis of such an inhibitory role of the frontopolar cortex at a conceptual and emotional level.

The activation in the ventromedial prefrontal cortex encompasses the frontopolar and the gyrus rectus (Figure 2). In the motor domain, only a frontopolar activation was detected when an individual imagined actions performed by another person (Ruby & Decety, 2001). The ventromedial prefrontal cortex has been reported to be involved in the process of making choices in incompletely specified situations, that is, in uncertain conditions (Elliott, Dolan, & Frith, 2000). This aspect is a strong characteristic of the type of task we used in the conceptual field and especially in the third-person perspective condition, whether in a neutral or an emotional context. In addition, the ventromedial prefrontal cortex has been hypothesized above all to be involved in the integration and computation of emotional and cognitive input (Houdé et al., 2001; Davidson & Irwin, 1999; Elliott, Frith, & Dolan, 1997) and to participate as such in what is more broadly called social cognition (Adolphs, 1999). This hypothesis appears particularly pertinent to the interpretation of the contrast (P3–P1) in our study because it isolates the component of taking another's point of view, which is an essential process involved in social cognition. Patients with lesions of the right ventromedial prefrontal cortex are significantly more impaired in empathic responses than patients with posterior lesions or lesions elsewhere in the frontal lobe (Shamay-Tsoory, Tomer, Berger, & Aharon-Perez, 2003). In addition, Adolphs (1999) has emphasized the role of the right ventromedial prefrontal cortex in social reasoning and decision making. In the P3 conditions, subjects had to evaluate either their mother's knowledge or the valence of the affect associated with a given situation out of several possibilities. In this study, the activation of the gyrus rectus may therefore be associated with a complex decision-making process about the other person, involving uncertainty and affective evaluation.

Previous neuroimaging studies have shown that the somatosensory cortex is involved in self versus other perspective taking, both at the motor and the conceptual level (Ruby & Decety, 2001, 2003). Such a finding suggests that the somatosensory cortex is involved in the construction of self-representation. Several neuroimaging studies suggest such a role for this region, which was initially considered exclusively as a primary sensory area (Penfield & Boldrey, 1937). In the motor domain, a study has reported a right postcentral gyrus activation during the simultaneous observation and execution of a finger movement (Iacoboni et al., 1999). The authors argued that this result was likely to be associated with "preservation of the sense of the self." Avikainen, Forss, and Hari (2002) came to the same conclusion about the putative functional role of the somatosensory cortex when interpreting somatosensory evoked fields recorded during simultaneous execution and observation of action. In the conceptual domain, Kircher et al. (2002) detected an activation in the postcentral gyrus both for explicit and implicit processing of self-descriptive adjectives. Note that the hemodynamic variation in the somatosensory cortex shows a pattern opposite to the one observed in the frontopolar cortex in the four conditions (Figures 2 and 4). This profile is interesting in light of the proposal that there is a functional interaction among the sensory cortex, the prefrontal cortex, and the amygdala (Grossberg, 2000). Adolphs (2002) has also recently argued that the orbitofrontal cortex exerts a modulatory influence on the somatosensory cortex. Accordingly, we further hypothesize that the frontopolar cortex exerts an inhibitory influence towards the somatosensory cortex.

The main effect of third-person perspective versus first-person perspective revealed activation in regions similar to those found in ToM studies, namely, medial prefrontal cortex, left temporoparieto-occipital junction, and left temporal pole (for a review, see Frith, 2001). This network has been previously detected in the comparison of third-person conceptual perspective versus first-person conceptual perspective in a neutral context

(Ruby & Decety, 2003). Our results demonstrate that this network is recruited in evaluating what another person knows or feels.

Activation was also detected in the posterior cingulate cortex in (P3–P1). This region was found in the comparison of P3 versus P1 in the motor domain. Involvement of the posterior cingulate cortex in the P3 conditions makes sense with its proposed role in evaluative processing (Zysset, Huber, Fersti, & von Cramon, 2002; Vogt, Finch, & Olson, 1992), because adopting the perspective of others does involve such an aspect.

### Main Effect of Emotion

It has been widely demonstrated, in both nonhuman and human primates, that the amygdala is involved in emotional processing and especially in fear processing (Phan, Wager, Taylor, & Liberzon, 2002; Rasia-Filho, Londero, & Achaval, 2000). However, as emphasized by Adolphs (2002), most studies that have investigated the cerebral correlates of emotion processing in humans used basic emotion (anger, fear, disgust, happiness, sadness). As a consequence, little is known about the cerebral processing of social emotions (e.g., pride, embarrassment, guilt, shame, admiration, and jealousy).

In our study, all regions detected in the main effect of social emotion (temporal poles, medial superior frontal gyrus, posterior cingulate gyrus, postcentral gyrus, and amygdala) are known to be involved in basic emotion processing (Phan et al., 2002; Damasio et al., 2000; Royet et al., 2000; Maddock, 1999). These results provide the first evidence of the involvement of the amygdala in social-emotion processing in healthy humans facing an ecological situation (but see Adolphs, 2003b, for a review, which suggests that the amygdala may have evolved in primates to process social information specifically).

The result of the interaction demonstrates that the amygdala is strictly involved in the emotional component of the mind-reading task as illustrated by the plot in Figure 3 showing that the perspective factor has no influence on the level of activity in the amygdala. This result sheds light on the still controversial issue of amygdala involvement in ToM (Adolphs, 2003a; Gallagher & Frith, 2003; Berthoz, Armony, Blair, & Dolan, 2002). According to our results, one way to explain the existing conflicting data between Baron-Cohen's study (1999) showing amygdala activation and other neuroimaging studies on ToM that did not detect any amygdala activation (for a review, see Gallagher & Frith, 2003) is to assume that the task used in Baron-Cohen's study involved an emotional component, whereas the tasks used in the other studies did not. Our results do not preclude a role of the amygdala in phylogeny or ontogeny of ToM but they provide evidence that the amygdala is not necessary for ToM expression.

The profile of activation of the amygdala that shows similar levels of activity for first- and third-person perspective in social–emotional processing also provides a strong argument for the understanding of the cerebral mechanism of empathy. It shows evidence that "one feels for the other," that is, that in order to make a decision about the putative emotional feeling of the other, one experiences the feeling one would have if one is facing the situation faced by the other. Participants' subjective reports collected after the positron emission tomography (PET) session support this interpretation. Indeed, subjects were predominantly aware of "projecting themselves" in the situations described by the stimuli, in the PE1 (9/10 subjects) as well as in the PE3 conditions (5/10 subjects). Moreover, most subjects (8/10) reported that they actually felt the emotion suggested in the stimuli. This result provides a neurophysiological substrate of the projection process, and a strong argument in favor of a simulation theory of mind reading. Finally, these results are congruent with and provide a neurophysiological explanation of the robust and consistent egocentric bias (tendency to impute one's own perspective to the other) evidenced in social psychology when assessing the other's mind (Nickerson, 1999; Davis, Conklin, Smith, & Luce, 1996).

### The Interaction Between Perspective and Emotion

An important goal of this experiment was to assess the effect of emotion on the level of activity in the regions involved in perspective taking. The analyses revealed a significant interaction effect in the left temporal pole and the right somatosensory cortex.

The temporal pole appears to be involved in third-person perspective, especially in an emotional context (Figure 4). This result is consistent with previous neuroimaging studies that have reported left temporal pole activation in both emotional processing and ToM tasks (Decety & Chaminade, 2003; Wicker, Perrett, Baron-Cohen & Decety, 2003; Frith, 2001). The interaction demonstrates enhanced involvement of this region for the combination of third-person perspective and emotion. It has been proposed that the temporal pole's activation in ToM is related to the autobiographical memory recall necessary to the ToM process (Gallagher & Frith, 2003). It is well known that emotions enhance memory consolidation (Canli, Zhao, Brewer, Gabrielli, & Cahill, 2000; Hamman, Timothy, Grafton, & Clinton, 1999). So when third-person perspective involves emotion, the left temporal pole enhanced activation may be related to the recall of more salient memories, which are particularly relevant and taken into account in the ToM process because of their emotional content.

The somatosensory cortex shows greater involvement in first-person perspective in an emotional context (Figure 5). It is noteworthy that the profile of activation in this region exhibits a high specificity for first-person perspective in an emotional context. Interestingly, participants' subjective reports after the PET session indicate that they were aware of ''projecting themselves'' in the situations described by the stimuli, especially in the PE1 condition (9/10), and that they actually felt the emotions elicited in the sentences (8/10). The somatosensory cortex was shown to be involved in first-person perspective (Ruby & Decety 2001, 2003), as well as in emotional processing (Adolphs et al., 2000; Adolphs, Damasio, Tranel, & Damasio, 1996). In a PET study using a paradigm of self-generated emotions, Damasio et al. (2000) reported an activation of SII. Our results confirm that the right somatosensory cortex is involved both in first-person perspective and in emotional processing. In addition, our study highlights the specificity of the right somatosensory cortex in the interaction between the two factors.

According to our results, it seems that in an emotional context subjects cannot prevent themselves from projecting themselves into the situation faced by the other person. This projection process is associated with a widely shared network of activation between self and other representation (main effect of social emotions). In such a shared situation, it might be especially important to rely on the neural mechanism involved in the distinction between self and other, to avoid confusion. This could explain the enhanced activation of the somatosensory cortex in first-person perspective, because somesthesy cannot be shared; if I feel, it is me (I feel so I am), it cannot be the other. In this sense, the somatosensory cortex appears to be an especially good candidate to participate in the distinction between self and other representation.

Furthermore, our results allow us to bridge social psychology and cognitive neuroscience by providing a plausible neurophysiological counterpart to the psychological model of perspective taking proposed by Gilovich's group. The shared network can be associated to the ''anchoring'' component and the distinction network to the ''adjustment'' component.

### Conclusion

Our study provides evidence that the frontopolar, somatosensory, and inferior parietal cortices play an important role in self/other distinction irrespective of the processing domain, be it motor, conceptual, or emotional. Self-perspective is associated with activation of the somatosensory cortex. We argue that third-person perspective requires regulation of self-perspective, and is correlated with activation in the frontopolar cortex, which is known to participate in executive inhibition, that is, the deliberate suppression of a cognition or response to achieve an internally represented goal (Nigg, 2001). In addition, two regions were found to be associated with the interaction between the emotional and perspective aspects of the task. The left temporal pole appears to be involved in third-person perspective, especially in an emotional context, whereas the somatosensory cortex exhibits a high specificity for emotional processing in first-person perspective. As a whole, this study provides important building blocks for our understanding of the neural mechanisms involved in human empathy and perspective taking showing both a shared neural network between self and other representations (involving the amygdala in a social–emotional context) for mutual understanding. Another set of regions accounts for the distinction between self and other representations (somatosensory cortex, frontopolar cortex, right inferior parietal cortex), irrespective of the processing domain, preventing the confusion that could derive from the shared network.

Finally, the results of the current study, combined with those of previous neuroimaging experiments (Ruby & Decety, 2001, 2003), demonstrate that there is not a single mechanism that accounts for the perspective-taking processing. Rather, perspective taking may be fragmented into a number of different major components including shared representations between self and other, executive inhibition, and the sense of agency. Each of these components is implemented in distinct but interacting neural networks.

## METHODS

### Subjects

The selection of the participants and the target persons for the third-person conditions were guided by the requirement to maximize the potentiality that subjects and targets would have distinct perspectives when encountering similar events. To satisfy this requirement, we selected individuals who had a specific expertise in a domain of knowledge (i.e., health sciences) and target persons who were naive in this domain but who were familiar enough with the participants to be able to adopt their subjective perspective. The target persons were the participants' mothers. Before their inclusion in the study, each subject was given a questionnaire to make sure their mother (1) was still alive, (2) had no particular education in medical sciences, and (3) had a good relationship with the subject.

Ten right-handed men (21.8 ± 1.3 years) enrolled between Year 3 and Year 6 of medical school were recruited. They gave written informed consent according to the Declaration of Helsinki. The study was approved by the local Ethics Committee (CCPPRB, Centre Léon Bérard, Lyon), and subjects were paid for their participation.

### Activation Paradigm

Subjects were scanned during four target conditions (PN1, PN3, PE1, PE3) repeated three times and presented in a pseudorandomized order counterbalanced across subjects (12 scans per subject).

Both the emotional content of the stimuli and the perspective taken by the subjects were manipulated in the four conditions according to a 2 × 2 factorial design (Figure 1): *The emotional factor* corresponds to the content of the stimuli.

In the neutral condition (N), subjects were presented with sentences containing health-science-related topics, from popular beliefs to more specialized questions (e.g., there are more births when the moon is round, pressure on the eyeball can induce heart failure, a congenital disease is hereditary, toxoplasmosis can be passed on by cat scratches; for more details, cf. Ruby & Decety, 2003). Subjects had to give an opinion about the truthfulness of each sentence.

In the emotional condition (E), subjects were presented with sentences depicting real-life situations likely to provoke a social–emotional reaction (cf. Table 2). Subjects had to give an answer about the reaction they thought would be aroused in such a situation.

*The perspective factor* corresponds to the perspective the participants were asked to adopt in order to answer the questions.

In the P1 condition, subjects were requested to answer the question according to their own perspective. In the PN1 condition, they were asked to give an opinion based on their own knowledge about the truthfulness of the sentence they read. In the PE1 condition, they had to choose among three adjectives, the one that best described the reaction they would have had if they had faced such a situation.

In the P3 condition, subjects had to answer the question according to the perspective of their mothers. In the PN3 condition, subjects were asked to imagine themselves in the ''mental shoes'' of their mothers in order to respond according to their mother's opinion, taking into account her knowledge and ignoring their own. In the PE3 condition, they had to choose among three adjectives the one that best described the reaction their mothers would have had if they had faced such a situation.

**Table 2.** Stimuli Presented in the Emotion-Laden Conditions

| *Examples of the Social Emotions Used* | *Examples of Stimuli* |
|---|---|
| Embarrassment | You catch someone listening behind your door. |
| | You are talking about someone and you realize that he is just behind. |
| | You give someone a present that is obviously not liked. |
| | You catch one of your colleagues when he steals in a shop. |
| Pride | A job promotion is promised to you. |
| Shame | Someone opens the toilet door that you have forgotten to lock. |
| | You break a glass at a friend's home. |
| Guilt | You are late for an appointment. |
| Admiration | Your dad is invited to talk on television. |
| Irritated | The checkout at the supermarket closes just when your turn arrives. |
| | Someone knocks over a coffee cup on your clothes. |
| Impressed | You have to talk in front of group of people. |

## Experimental Paradigm

In all conditions, subjects were presented with sentences written in black on a white background during a fixed period of 6 sec. For each stimuli, subjects had to choose one out of three answers presented.

In the neutral conditions, a heading reminding the subjects which perspective they were asked to adopt was provided with the stimuli (''according to you'' for PN1 and ''according to your mother'' in PN3), as well as three possible answers. Depending on the stimuli, subjects were presented with distinct answer scales (of a set of six different scales) that were composed of synonymous words, that is, ''true/without opinion/false,'' ''exact/no idea/inexact,'' ''sure/perhaps/absolutely not,'' ''yes/maybe/no,'' ''affirmative/don't know/negative,'' ''definitely/can't say/not true.'' All scales were equally presented in each PN conditions.

In the emotional conditions, the structure of each sentence made clear who was target of the task (e.g., ''You are late for an appointment,'' in the PE1 condition) or (''Your mother is late for an appointment,'' in the PE3 condition). Again, subjects were presented with distinct answer scales. Depending on the type of stimuli, the answers were composed of three adjectives describing possible reactions in the situation depicted in the sentence (''shocked/indifferent/sympathizer,'' ''panicked/bothered/calm,'' ''angry/upset/resigned,'' ''suspicious/carefree/excited,'' ''impressed/proud/detached,'' ''irritated/embarrassed/relaxed''). All PE conditions were composed of the same number of each of these scales (i.e., each scale was presented for 1/6 of the stimuli in a condition).

In the P1 and P3 conditions, subjects were presented with the same set of sentences but in a different order (20 sentences per condition). The order of presentation of the conditions across subjects was manipulated to counterbalance the effect of novelty of sentence sets between subjects for each condition. Subjects responded by pressing the corresponding button on a keypad that rested on their chest.

After the PET experiment was completed, participants were asked to complete a brief questionnaire to assess their perception of the difficulty of the task and to identify the strategy they used.

### Scanning Procedure

A Siemens (Milwaukee, WI) CTI HR+ (63 slices, 15.2-cm axial field of view) PET tomograph with collimating septa retracted operating in 3-D mode was used. Sixty-three transaxial images with a slice thickness of 2.42 mm without gap in between were acquired simultaneously. A venous catheter to administer the tracer was inserted into an antecubital fossa vein in the left forearm. Correction for attenuation was made using a transmission scan collected at the beginning of each study. After a 9-mCi bolus injection of $H_2{}^{15}O$, scanning was started when the brain radioactive count rate reached a threshold value and continued for 60 sec. Integrated radioactivity accumulated in 60 sec of scanning was used as an index of regional cerebral blood flow (rCBF).

In all conditions, an NEC (Tokyo, Japan) projector (800 × 600 pixels) displayed the stimuli on a screen located at the back of the camera. A mirror placed in front of the subjects' eyes allowed them to see the projected images by reflection. The resultant distance from the eyes to the screen was approximately 50 cm (corresponding field of view: 42° in the horizontal dimension and 32° in the vertical one). A Power Macintosh computer (Apple Inc., Cupertino, CA) with the SUPERLAB software was used to control the display processing and to record both the responses and the reaction times.

### Data Analysis

Images were analyzed with the Statistical Parametric Mapping software (SPM99, Wellcome Department of Cognitive Neurology, London, UK) (Friston et al., 1995), implemented in MATLAB 5 (Math Works, Natick, MA). For each subject, images were realigned to the first scan then normalized into the MNI stereotactic space. Data were convolved using a Gaussian filter with a full width half maximum (FWHM) parameter set to 10 mm.

Global activity for each scan was corrected by grand mean scaling. The condition (covariate of interest) and subject (confound, fixed effect) effects were estimated voxelwise according to the general linear model. Linear contrasts were calculated to identify significant differences in voxel activity between conditions, and were used to create an SPM {t} map. The SPM {t} maps were thresholded at $p < .05$ corrected for the whole brain volume. We report all foci of activation that survived correction at $p < .05$ plus those regions surviving an uncorrected threshold (of $p < .001$ for the main effect and $p < .01$ for the interaction effect) for which we had a strong a priori hypothesis. We retained clusters when their size exceeded 10 voxels (extent threshold $k = 10$). Anatomical identification was performed using the atlases of both Talairach and Tournoux (1988) (implemented in SPM99, TSU) and of Duvernoy (1991).

Statistical analysis was performed to examine the main effects of both perspective ([(PN3 + PE3) – (PN1 + PE1)] and [(PN1 + PE1) – (PN3 + PE3)]) and emotional [(PE1 + PE3) – (PN1 + PN3)] factors and their possible interaction ([(PE3 − PE1) – (PN3 − PN1)] and [(PE1 − PE3) – (PN1 − PN3)]).

Post hoc inspection of the data was used to assess task-related regional activity. It represents adjusted rCBF relative to the fitted mean, in each task, in order to demonstrate the differential involvement of regions of interest in the four experimental conditions.

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