

The role of ‘shared representations’ in social perception and empathy: An fMRI study

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Evidence suggests that we use the same mechanisms for both producing and perceiving actions. Such ‘shared representations’ may also underlie social perception and empathy. However, this idea raises some important and as yet unresolved questions: (i) how do we distinguish other-orientated empathic responses from a self-orientated reactions such as *personal* distress and (ii) what are the neural substrates underpinning these processes? We employed event-related functional magnetic resonance imaging (fMRI) to explore whether ‘shared representations’ were recruited to decode dynamic social stimuli in 12 healthy volunteers. We used an adapted version of the Profile of Non-Verbal Sensitivity (Rosenthal, H., Hall, J.A., DiMatteo, M.R., Rogers, P.L., Archer, D., (1979). Sensitivity to nonverbal communication: the PONS test. The Johns Hopkins University Press, Baltimore) which taps social perception using brief silent video clips. Participants chose one of two words that best described the state conveyed by the actor, or in the control condition using the same clips, the word describing which parts of the body were visible (non-social labelling). Off-line self-report measures of empathy and personal distress engendered by thoughts about others, were also given along with an experimentally-derived index of the degree of self–other overlap during social perception. Brain activation specific to the main experimental condition was found in the inferior frontal gyrus (BA44) and premotor areas (BA6) consistent with the use of ‘shared representations’. Somatosensory areas such as the insula and supramarginal gyrus (BA40) were also activated suggesting that participants constructed a qualitative representation of the target state. Activity in the rostral anterior cingulate was associated with self-reports of *personal* distress and increased blood flow to the anterior cingulate (BA24) and inferior parietal cortex (BA40) was related to self–other overlap.

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Introduction

Empathy is a higher order construct which can be broken down into: (i) cognitive empathy—‘understanding and predicting someone else’s mental state’ and (ii) affective empathy—‘*experiencing* an [appropriate] emotion as the result of someone else’s mental state’ (Baron-Cohen and Wheelwright, 2004, *emphasis added*). Empathy is thought to require adequate social perception which includes ‘the analysis of eye-gaze direction, facial expressions, body movements and other types of biological motion’ (Pelphrey et al., 2004) but also entails the comprehension of intentionality and more complex second order mental states (theory of mind—ToM). One important question in social cognitive neuroscience is whether empathy can be achieved merely by following a rule-based algorithm or whether a qualitative representation of another’s emotional or other mental state is required. This ‘*experiencing*’ aspect of affective empathy suggests that it goes beyond social perception which may be feasibly achieved using a series of rules. Cognitive empathy may also entail a covert representation of emotional arousal experienced by the target—and this aspect may also be less amenable to a rule-based strategy.

The most comprehensive study to explore, albeit indirectly, the neural substrates of covert arousal in social perception used 3D lesion mapping of the brains of 108 people with focal damage (Adolphs et al., 2000). Damage to cortical somatosensory-related areas was found to correlate with impairments in naming emotions and the appreciation of emotional concepts. The insula alone was specifically implicated in conceptual knowledge independent of lexical stimuli. The authors interpret these data as being consistent with the idea that covert somatosensory online representations are constructed when emotion judgements are made.

A more recent study involved a group of people with pure autonomic failure who were found to perform worse than controls on a more sensitive, subtle emotion attribution task based on a series of written vignettes (Heims et al., 2004). Interestingly, this group performed similar to controls on a simple cruder emotional

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expression labelling task. The authors conclude that empathic bodily responses may be called upon to identify the emotional states from the more subtle vignettes. This suggests that stimuli that are more difficult to decode are more likely to prompt a qualitative as opposed to rule-based strategy (see Adolphs, 1999 for a discussion).

Further support for the role of cognitive representations of arousal in social perception comes from a series of studies exploring vicarious pain. Singer et al. (2004) had participants receive both a painful stimuli and observe a signal that their loved one, who was present in the same room, had received the same stimuli. Insula activation was found in both the self and other condition. In addition, activation was observed in the rostral anterior cingulate cortex (ACC) and linked to both the personal and vicarious experience of pain. Consistently, activity in this area also correlated with scores on self-report empathy measures. Similarly, Jackson et al. (2005) found ACC activation to be strongly correlated with the assessment of a strangers pain from photographs, and Morrison et al. (2004) found an association between ACC activation and vicarious pain resulting from a viewing a video of an unknown person receiving a pinprick, suggesting that such vicarious pain is not limited to loved ones (but see Leibenluft et al., 2004).

These studies are all consistent with the theory of simulation: the ‘attempt to replicate, mimic or impersonate the mental life of the target’ (Gallese and Goldman, 1998). The discovery of neurones in the premotor cortex that are activated in response to both observing and executing an action (Gallese and Goldman, 1998) also fits well with a simulation account of social perception and empathy. Further support for this view can also be found in the earlier onset of the haemodynamic response for the self-perspective suggesting that it may be more readily accessible (or privileged) (Decety and Jackson, 2004; Grezes et al., 2004).

A similar concept has also been proposed based on the use of ‘shared representations’ wherein ‘perception and action share common neural and cognitive codes’ (Decety and Sommerville, 2003). Grezes and Decety (2001) undertook a meta-analysis of approximately 30 functional neuroimaging studies exploring action generation, action simulation, action observation and verb generation. The main areas of activation specific to action simulation studies were the premotor cortex and dorso-lateral prefrontal cortex (DLPFC), the supramarginal gyrus and the superior parietal lobe. There are also data to suggest that this strategy may transfer to social actions. In a recent study, Cummins et al. (2005) found that children diagnosed with motor difficulties had problems recognising static and dynamic expressions of emotions compared to a well-matched control group (see also Botvinick et al., 2005; Carr et al., 2003; Decety and Chaminade, 2003; Hadjikhani and DeGelder, 2003; Leslie et al., 2004; Wicker et al., 2003).

However, if we rely on the similar mechanisms to execute and perceive actions whether social or not, the nature of the distinction between self and other becomes important (for instance, see Kilner et al., 2003). It is unlikely that this ‘sharedness’ is absolute (Decety and Jackson, 2004; Ramnani and Miall, 2004; Ruby and Decety, 2004) with processes such as mental flexibility and self-regulation required to maintain separateness (Decety and Jackson, 2004). Of relevance is the current debate in the empathy for pain literature as to whether vicarious pain ordinarily includes the sensory aspect of pain such as intensity and location along with the affective aspects such as unpleasantness or whether the focus is selective emphasising the affective elements alone (Avenanti et al., 2005; Singer and Frith, 2005). Social psychologists have long considered the degree of overlap between the self and other in perspective-taking as an

important issue. For instance, Davis et al. (1996) had participants watch a film of a person speaking about personal events and asked them to ‘imagine themselves’ in the situation, ‘imagine the target’ or simply watch the video. Participants in both the ‘imagine’ conditions attributed a higher proportion of personality traits to the character that they had previously attributed to themselves, suggesting an increased reliance on the self-concept during perspective-taking.

Davis (1994) also points out that perspective-taking can prime people for affective states which are non-empathic such as feelings of unease and personal distress (Davis, 1980; Eisenberg and Strayer, 1987) which are self-orientated as opposed to other-orientated such as sympathy or concern (Eisenberg et al., 1989). This distinction is rarely considered within the neuroscientific literature, despite the fact that it is crucial to the development of an empathy model. Batson et al. (1987) suggest that such self-orientated responses stem primarily from thoughts as to how the person would feel in the same situation. However, an empathic response and a personal response of distress may also share some cognitive and neural patterns (Adams, 2001).

In terms of neural correlates, the inferior parietal lobe (BA40) is likely to be involved in distinguishing the self from other (Blakemore, 2003; Decety and Jackson, 2004). In one study, participants were required to take a first or third person stance in response to situations involving social emotions and a neutral condition. Adopting a third person perspective was related to increased blood oxygenated level dependant (BOLD) signal in areas such as the inferior parietal lobe (Ruby and Decety, 2004).

Regarding ‘personal distress’, the rostral anterior cingulate is thought to be involved in autonomic arousal, and in particular the second-order or context-driven representation of arousal states. This brain area was found to be recruited in the intentional modulation of autonomic responses during a biofeedback paradigm (Critchley et al., 2001). The insula, on the other hand, may be implicated in conscious awareness of such states. It is therefore plausible that both these areas are involved in the experience of ‘personal distress’ which may also require an adjustment in arousal levels to reflect the current context and the vicarious nature of the stimuli.

The aims of this study were to explore the neural correlates of social perception by using a task based on naturalistic dynamic full body stimuli in an fMRI paradigm. The Profile of Non-Verbal Sensitivity or PONS (Rosenthal et al., 1979) is a social perception task based on 2 s video clips of a female actor conveying various states using facial and bodily expressions and gestures. A ‘body only’ condition is included which is inherently difficult to decode, perhaps due to an absence of firm pre-existing knowledge as to the specific gestures relating to the states of mind depicted (Adolphs, 1999). It was reasoned that the absence of such knowledge may preclude a rule-based strategy and invoke an alternative, more qualitative approach (see Heims et al., 2004 above). A well-matched control condition based on the same video clips was also included. In addition, the neural correlates of self-reported personal distress were explored using a well-validated self-report measure (Davis, 1980). The Davis trait task (see above) was also used to tap the use of the self-concept in perspective-taking.

Hypotheses

- During the revised PONS (PONS-r), a social perception task postulated to require empathy, brain areas associated with the use of a ‘shared representation’ network, i.e. premotor cortex/

precentral (BA6) gyrus, inferior frontal gyrus (BA44/45) and somatosensory areas such as the insula and supramarginal gyrus, will be activated.

- Increased BOLD signal will be observed in the inferior parietal lobe (BA40) consistent with the distinction between self and other. We predict that activity in this area will also correlate with self–other overlap on a trait attribution task.
- A distinct pattern of neural activation will be observed in participants who self-report high levels of personal distress. This is likely to be in brain areas involved in the representation of autonomic arousal and interoceptive states such as the anterior cingulate and insula.

Methods

Measures

The revised Profile of Non-Verbal Sensitivity (PONS-r)

The PONS (Rosenthal et al., 1979) is a social perception task based on 2 s video clips of one female actor conveying various states of mind using facial and bodily expressions and gestures (see Supplementary Fig. 1). There are 20 clips which are then further divided into ‘face’, ‘body’ and ‘face and body’ together otherwise known as ‘figure’, i.e. totalling 60 clips. All the clips were digitised to allow computerised presentation in an fMRI paradigm and the measurement of reaction times. The original version also included 2 sound conditions which were dropped due to potential interference from the noise of the scanner.

There were 3 conditions (see Fig. 1):

- 1) button press—a ‘stop/go’ task simply requiring a button press in response to ‘go’.
- 2) non-social labelling—participants are shown all 60 video clips but have to indicate how much of the actor was displayed (physical channel) from one of two options, i.e. her body, face or ‘figure’.
- 3) social perception—participants are shown the same 60 video clips but have to choose from 2 alternative words that best describe the state being conveyed.

The final task consisted of 180 items: 60 social perception items, 60 non-social labelling items, a 60 button press items. Participants chose one of two response alternatives. In the social perception and non-social labelling task, each video-clip lasted approximately 2 s although the response choices were displayed for 8 s (see Fig. 2).

Social perception labels: The correct answers and foils were refined and updated. Colleagues suggested alternative labels and final selection was made on the basis of majority opinion.

Foils: In the social perception task, 5 foils were similar states, 5 were the same broad valence (i.e. positive or negative) and 5 were the opposite valence.

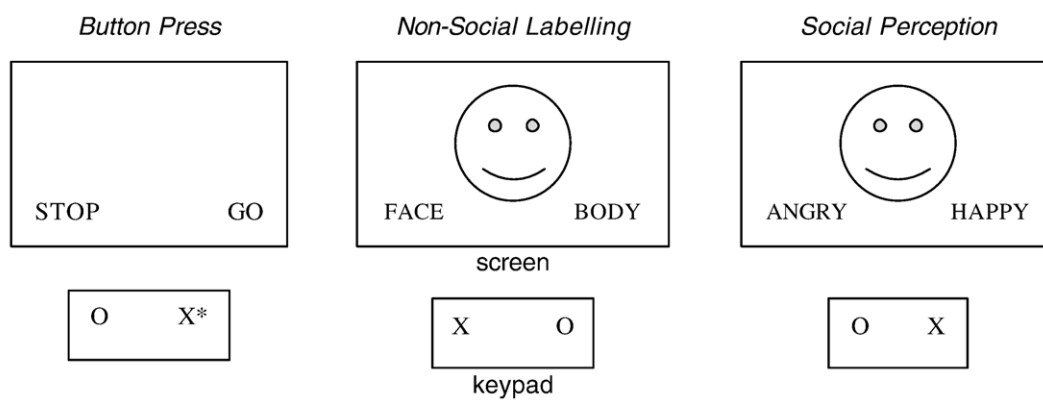
Control foils: Each possible response alternative, i.e. body, face, figure, was used equally and presentation balanced for left or right. Similarly, in the button press condition, ‘go’ appeared on the right 50% of the time.

Stimulus presentation was also randomised. All the variables were correlated with the item presentation number to see if there was a tendency for any one condition, response alternative or physical channel to be overrepresented at the beginning or end of the task. The only significant variable was ‘face’ in the social perception condition meaning that there was a slight tendency for ‘face only’ clips in this condition to appear near the beginning—however, this was a low correlation ($r = -0.273$, $n = 20$, $P = 0.035$) and did not hold for both non-social labelling and social perception conditions combined.

The self–other overlap trait task

Participants were asked to select trait words that best described themselves (or the actor in the video), from a shortened ‘Trait Adjective Checklist’ (Loehlin and Nichols, 1976) as described in Davis et al. (1996). As a result of piloting (see Lawrence, 2004), the list was pared down to 75 adjectives by using the traits that were endorsed most frequently whilst ensuring an even balance of positively and negatively-valenced traits. Participants were given this list immediately after the fMRI scan and asked to place a tick next to those adjectives that best describe the personality of the woman in the video clips. They were asked to respond with the first word that came to mind and advised that there were no wrong or right answers.

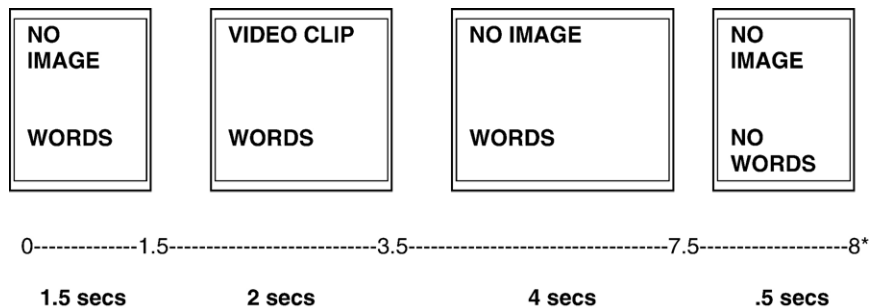
Participants were also sent the same list by post, accompanied by instructions to place a tick beside any adjective that



X = correct answer and O = incorrect answer

Each stimulus runs through the cycle detailed in Figure 2.

Fig. 1. Example of stimuli in each condition.



*words disappear once a choice has been made and at 8 secs the cycle for next stimuli commences.

Fig. 2. Cycle for each stimuli in the PONS-r.

they might use in describing themselves to someone else. They were told, “your behaviour will vary with the situation, of course, so place a tick beside the adjectives which might apply to you frequently, even though they are not appropriate all the time.”

Two overlap scores were then calculated according to Davis et al. (1996): (i) percentage of the ‘self’ traits that were endorsed for the target (self-overlap) and (ii) percentage of a ‘target’ traits that were endorsed for the self (target-overlap). Participants were free to endorse as few or many traits as they wished.

Self-report measures

Two self-report measures were administered: the Empathy Quotient (EQ—Baron-Cohen et al., 2003; Baron-Cohen and Wheelwright, 2003, 2004; Lawrence et al., 2004) and the Interpersonal Reactivity Index (IRI—Davis, 1980).

The EQ has 40 test items comprising statements such as ‘I am good at predicting how someone will feel’ or ‘I get upset if I see people suffering on news programmes’.

Responses are given on a 4 point scale ranging from ‘strongly agree’ to ‘strongly disagree’. Participants receive 0 for a ‘non-empathic’ response, whatever the magnitude, with 1 or 2 for an ‘empathic response’ depending on the strength of the reply and so the total score is out of 80. Principal components analysis has shown the scale to have 3 main factors: (i) cognitive empathy—‘I get upset if I see people suffering on news programmes’, (ii) emotional reactivity which includes items that measure affective empathy such as ‘seeing people cry doesn’t really upset me’ and (iii) social skills—‘I find it hard to know what to do in a social situation’ (Lawrence et al., 2004).

The IRI includes subscales that measure: perspective-taking which fits with traditional definitions of cognitive empathy; empathic concern which specifically addresses the capacity of the respondent for warm, concerned, compassionate feelings for others, i.e. a facet of affective empathy; fantasy items which measure a tendency to identify with fictional characters; and personal distress which is designed to tap the occurrence of self-orientated responses to others’ negative experiences. Each subscale consists of 7 items each measured on a 5 point Likert scale ranging from ‘does not describe me at all’ to ‘describes me very well’. The maximum score on any one subscale is therefore 35. The personal distress subscale is of particular interest here and includes items such as ‘in emergency situations, I feel apprehensive and ill-at-ease’ and ‘I sometimes feel helpless when I am in the middle of a very emotional situation’.

Pilot study

The PONS-r was piloted on 9 men and 11 women recruited with a mean age of 35.1 years (± 10.43). The social perception items evoked more errors as expected, followed by the ‘non-social labelling’ items and the lastly the button press condition. Accuracy on the mental state items was remarkably similar to the normative data, i.e., 72.8% in the current study as opposed to 77% in the original data sets (Rosenthal et al., 1979) and high enough to be above chance and low enough to indicate a lack of ceiling effects.

Procedure

After giving informed consent, participants were shown written standardised instructions for the PONS-r. They were then given a practice run consisting of 9 items and were allowed to repeat this until they felt comfortable with the task. Immediately after the fMRI scan, participants were asked to fill out the trait list detailed above. In a separate testing session, participants also completed the self-report empathy measures—the EQ and IRI (see above).

Participants

An fMRI study was conducted with 12 right-handed healthy volunteers. There were 6 men and 6 women with a mean age of 32.2 years (± 9.95). None of the participants had a history of mental or neurological illness or any contraindications for scanning. Mean verbal IQ as predicted from the National Adult Reading Test (NART—Nelson, 1982) was 119.4 (± 5.9). All participants were also prescreened with the EQ and scored within normal range as observed in previous studies (Baron-Cohen and Wheelwright, 2004).

Image acquisition

Participants were scanned using a GE Signa 1.5 T Neuro-optimised MR system (General Electric, Milwaukee, WI, USA). After collection of high resolution structural scans (3.3 mm thick) in the axial plane, an event-related design was employed with 60 clips in each of the 3 conditions presented in a randomised order, therefore, totalling 180 clips. With a TR of 2 s and each of 180 stimuli lasting 8 s (video clips 2 s and ISI 6 s), 720 gradient echo echoplanar T2* weighted images were acquired at each of 16 near-axial, 7 mm thick planes. Accuracy rate and reaction time were also measured.

Image analysis

The data were analysed using in-house software (XBAM <http://www.brainmap.it/>). Analysis methods have been described in

Table 1
Measures of central tendency for behavioural data: self-report scales and trait task

	Empathy quotient			Interpersonal reactivity index			% trait overlap	
	Cognitive empathy	Emotional reactivity	Social skills	Empathic concern	Perspective-taking	Personal distress	Self	Target
Mean	16.45	8.55	7.8	18.55	18.09	–	–	–
SD	4.25	3.36	2.4	4.37	3.45	–	–	–
Median	–	–	–	–	–	12	36.84	51.61
Range	12	12	8	15	11	13	65.38	79.49

depth elsewhere (Brammer et al., 1997; Bullmore et al., 1999). In summary, motion artefacts were corrected and the data set smoothed using a Gaussian filter (± 8 mm Full Width Half Maximum—FWHM). Individual brain activation maps were then created using gamma variate functions (peak responses at 4 and 8 sec) to model the BOLD response. Following a least squares fitting of this model, a goodness of fit statistic known as the sum of squares ratio (SSQ¹) was estimated at each voxel. This was followed by permutation testing (Brammer et al., 1997) to determine significantly activated voxels specific to each condition ($P < 0.001$). Group activation maps were then created by testing the median SSQ for each participant at each voxel in standard stereotactic space (Talairach and Tournoux, 1988).

Results

Behavioural

There were differences (offline pilot vs. online fMRI) in accuracy rates for decoding the ‘figure’ items ($t = 6.074$, $df 30$, $P < 0.001$). The ‘fMRI’ group performed significantly less well with a mean score of 12.6 (63%) vs. 15.8 (79%) in the offline group. This was probably due to the video clips being viewed at a further distance in the fMRI task due to restrictions of the scanner suite.

Next, the relationship between the individual subscales on the two self-report measures and performance on the PONS-r during the fMRI study was explored² (see Table 1).

Scores on the ‘social skills’ component of the EQ were positively associated with superior performance on the social perception task ($r = 0.657$, $P = 0.028$) which seemed to be driven by accuracy at decoding stimuli from clips of the body alone, i.e., the more difficult clips ($r = 0.739$, $P = 0.009$). Scores on the ‘personal distress’ subscale of the IRI showed a significant correlation^{3,4} with reaction time on the mental state labelling task ($r = 0.510$, $P = 0.054$) and a trend between scores on this subscale and accuracy on mental state labelling of ‘face’ items of the PONS-r ($r = 0.418$, $P = 0.100$). No significant associations were observed between performance and the remaining subscales.

Turning to the cognitive measure of self–other overlap or the ‘trait task’, preliminary analyses suggested associations between self–other overlap and accuracy on the ‘body’ items.

¹ SSQ is the ratio between the sum of squares due to the model fit and the residual sum of squares. It is therefore an estimate of the mean power of neural response, similar to a z score without being reliant on the assumptions of normality.

² One participant failed to return the IRI and EQ.

³ One-tailed tests were used as predictions were a priori.

⁴ Spearman’s Rho correlational analyses were used due to non-normally distributed data.

This was stronger for ‘self-overlap’ score, i.e. the percentage of the ‘self’ traits that were later endorsed for the target ($r = -0.651$, $P = 0.015$ —based on non-parametric correlations). This suggests that in this instance an increase in the use of the self-concept in perspective-taking is related to a decrease in accuracy.

fMRI analyses

Generic brain activation maps (GBAM—Brammer et al., 1997) were constructed to depict mean power of functional activation.

Main effects

In order to examine brain activation specific to the experimental condition, analyses were conducted to explore significant differences in activation between ‘social perception’ and ‘non-social labelling’. The peaks of activation specific to the ‘non-social labelling’ task were located posteriorly in the precuneus (BA7: talairach co-ordinates $x = 4$, $y = -56$, $z = 42$) extending inferiorly through the cingulate gyrus to the posterior cingulate, and the precentral gyrus (BA4: 43, -15 , 37) extending posteriorly through the post central gyrus into the inferior parietal lobule/supramarginal gyrus (BA40).

Activation specific to the ‘social perception’ (see Fig. 3⁵ and Table 2) task was observed in the dorso- and ventro-lateral prefrontal cortex (VL/DLPFC), inferior frontal gyrus (BA44), cingulate gyrus (BA32), superior temporal gyrus, premotor cortex (BA6), inferior parietal lobe (BA40) including the supramarginal gyrus and angular gyrus, the superior parietal lobe and the fusiform and parahippocampal gyri.

Behavioural correlations

On the basis of associations within the behavioural data (see above), correlational analyses were conducted to explore the relationship between brain activation in the social perception condition (as contrasted to the non-social labelling task) and self-report, i.e. scores on ‘personal distress’ and ‘social skill’ subscales. Analysis methods are described in full elsewhere (Mataix-Cols et al., 2004). Analyses were conducted on the whole brain; however, only frontal and medial dorsal areas are reported in line with predictions. Activation that positively correlated with ‘personal distress’ scores includes the medial frontal gyrus (BA10), superior frontal gyrus (BA8), cingulate gyrus (BA24) and putamen (BA68) (see Table 3 and Fig. 4).

⁵ Activation significant at a voxel wise error rate of $P = 0.05$ and clusterwise of $P = 0.01$.

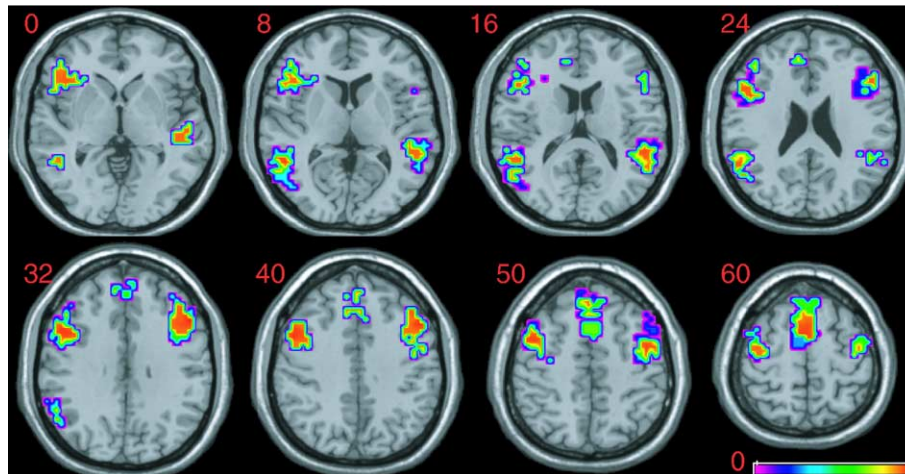


Fig. 3. Generic brain activation map (GBAM) representing social perception > non-social labelling task. Left = left. The colour bar represents increasing SSQ ratio and hence relative level of activation.

An area on the medial frontal gyrus (BA8) was, however, negatively related to personal distress.

Areas that correlated with self-reported ‘social skills’ from the EQ include the putamen, premotor cortex (BA6), middle temporal gyrus and anterior cingulate (see Table 4 and Fig. 5).

Of interest is the observation that the magnitude of BOLD response in an area of the anterior cingulate (BA24) slightly more lateral than that observed in those high on self-reported ‘personal distress’ (−7, 26, 15) was also negatively correlated with ‘social skills’ (−14, 26, 15)—see Fig. 6.

Lastly, brain activations that correlated with the self–other overlap score were examined (see Fig. 7). In line with the predictions, activation in parietal areas is also reported.

There was a positive association between ‘self-overlap’ and activation in the anterior cingulate (BA24/32), the supramarginal

gyrus (BA40) and precuneus (BA7). In addition, increased BOLD signal in the superior temporal gyrus, parahippocampal gyrus and medial frontal lobe was also observed (Table 5).

Instances where the magnitude of brain activation negatively correlated with ‘self-overlap’ include the putamen, left inferior parietal lobe (BA40), superior temporal gyrus and right inferior frontal gyrus.

Discussion

These data suggest that brain areas associated with both ‘shared representations’ and ‘theory of mind’ were activated during a social perception task based on dynamic stimuli. These include the premotor cortex/precentral gyrus (BA6), inferior

Table 2
Social perception > non-social labelling task

Brain region	x	y	z	No. of voxels	P value
<i>Left</i>					
Middle frontal gyrus (BA46/DLPFC), extending to: Inferior frontal gyrus (BA44/Broca’s) Precentral gyrus (BA6)	−47	19	26	265	0.0002
Middle temporal gyrus (BA21), extending to: Medial occipital gyrus (BA19) Superior temporal gyrus/sulcus (BA22) Inferior parietal lobule (BA40) Supramarginal gyrus (BA40) Angular gyrus (BA39)	−47	−44	−2	93	0.003
<i>Right</i>					
Middle frontal gyrus (BA46/DLPFC), extending to: Insula Inferior frontal gyrus (BA44) Precentral gyrus (BA6)	51	26	26	163	0.0002
Superior frontal gyrus (BA6/8), extending to: Cingulate gyrus (BA32)	0	7	48	156	0.0005
Fusiform gyrus (BA20), extending to: Inferior temporal gyrus (BA20) Parahippocampal gyrus (BA36) Superior temporal gyrus (BA22) Middle temporal gyrus (BA21)	36	−26	−35	127	0.0007

Table 3
Brain activation correlated with self-reported ‘personal distress’

Brain region	x	y	z	No. of voxels	P value
<i>Positive correlation</i>					
Right					
Middle frontal gyrus (BA10)	25	41	-2	11	0.0002
Superior frontal gyrus (BA8)	25	26	48	11	0.0002
Left					
Mid-anterior cingulate (BA24)	-7	26	15	9	0.0002
Cingulate gyrus (BA24)	-14	7	36	8	0.001
Putamen (BA68)	-18	11	4	5	0.007
<i>Negative correlation</i>					
Left					
Medial frontal gyrus (BA8)	-11	33	37	3	0.0007

frontal gyrus (BA44) and medial frontal lobe. In addition, the anterior cingulate appears to be activated during the self-orientated experience of personal distress. Activation in this area was also associated with a high degree of overlap between the self and other concepts. Finally, the inferior parietal lobe was also associated with the degree of ‘sharedness’ between the self and target with *less* activation correlating with the degree to which the participants identified with the actor using knowledge about their self. This suggests that this structure is involved in maintaining the distinction between self and other.

The activation of a ‘shared representations’ network in this study is consistent with a theory of social perception modelled on action perception (Decety, 2002). To find the bilateral premotor cortex/precentral gyrus (BA6) activated in a social perception task adds some weight to the validity of an action perception model which implicates imitation as the basis for the perception of other people’s state of mind. This is also consistent with the existence of mirror neurones in the premotor cortex. ‘Shared representations’ may be of particular use in the current paradigm being based on stimuli that were both dynamic and difficult to decode although more studies are needed to assess the generalisability of such a strategy.

As expected, activation during this task was also observed in the medial frontal lobe (BA6/8/9), an area that has long been associated with tests that require mental state inferences (see Frith and Frith, 2003 for a review), and decoding facial expressions of

Table 4
Brain activation correlated with self-reported ‘social skills’

Brain region	x	y	z	No. of voxels	P value
<i>Positive correlations</i>					
Right					
Putamen	29	-7	15	17	0.0002
Middle temporal gyrus (BA21)	61	-29	-13	5	0.003
Inferior frontal gyrus (BA45)	51	26	20	5	0.0087
Precentral gyrus (BA4)	36	-22	48	2	0.0026
Medial frontal lobe (BA8)	14	26	48	2	0.0087
Left					
Middle frontal gyrus	-36	11	53	6	0.0011
<i>Negative correlations</i>					
Left					
Anterior cingulate (BA24)	-14	26	15	14	0.0002
VLPFC (BA10)	-29	37	-2	3	0.0054
Right					
Anterior cingulate (BA32)	22	41	9	4	0.0002

complex emotions (Shaw et al., 2005) the majority of which have been reliant on static rather than dynamic stimuli. The data therefore suggest that the perception of dynamic social stimuli involves both traditional ToM areas which may be specialised for more complex mental state attribution including second order states, and a ‘shared representation’ system which may be helpful in decoding the more bodily based attributes of the target state, indicating that these two systems may work in tandem (see Jacob and Jeannerod, 2005 for a discussion). Further studies have implicated the DLPFC in some aspects of ToM reasoning, perhaps exerting its influence through domain general activities such as cognitive flexibility (Eslinger, 1998; Shamay-Tsoory et al., 2002). In addition, activation of the superior temporal sulcus is consistent with this being a dynamic task. It is also possible that the ACC activation observed may reflect increased task difficulty and attentional demands inherent in decoding dynamic as opposed to static stimuli.

The bilateral activation of the inferior frontal gyrus (BA44) including Broca’s area in the current study is also of particular interest due to the recent suggestion that this area may too contain a mirror system (Molnar-Szakacs et al., 2005) being adjacent to premotor areas (but see Ramnani and Miall, 2004 for discussion).

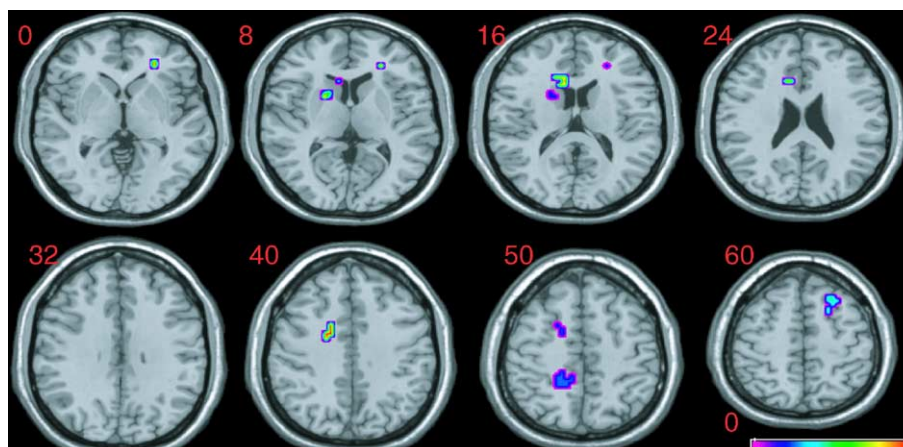


Fig. 4. Brain regions where magnitude of activation positively correlates with self-reported ‘personal distress’.

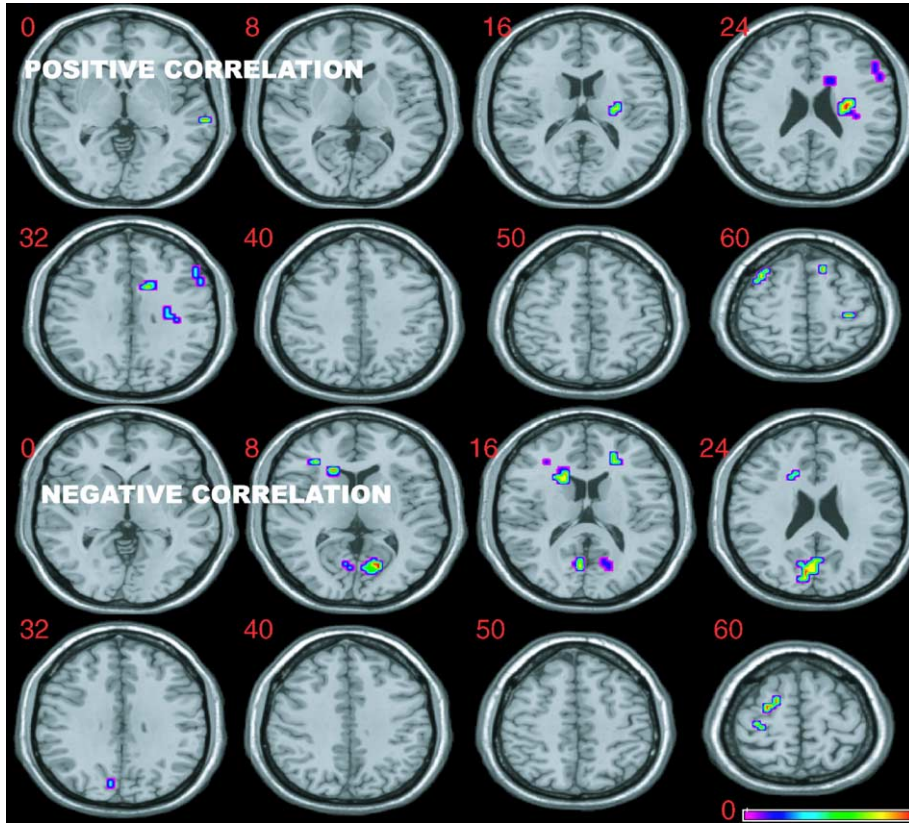
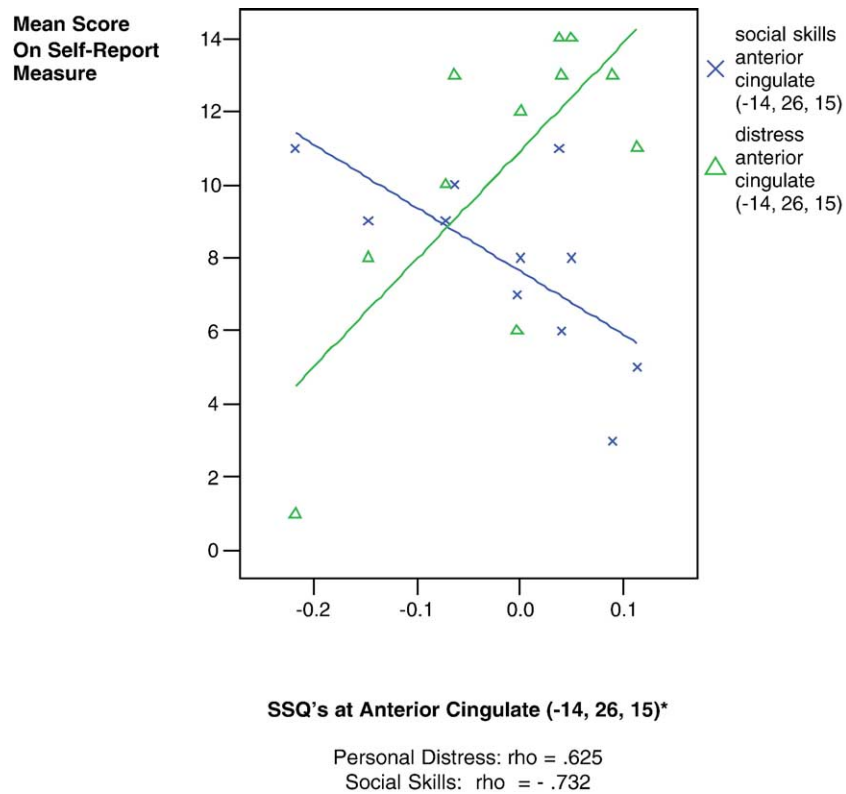


Fig. 5. Brain regions where magnitude of activation correlates with self-reported 'social skills'.



* please note a negative value here simply means relative to contrasting condition.

Fig. 6. SSQs at peak of activation in anterior cingulate and scores on 'personal distress' subscale of IRI and 'social skills' subscale of EQ.

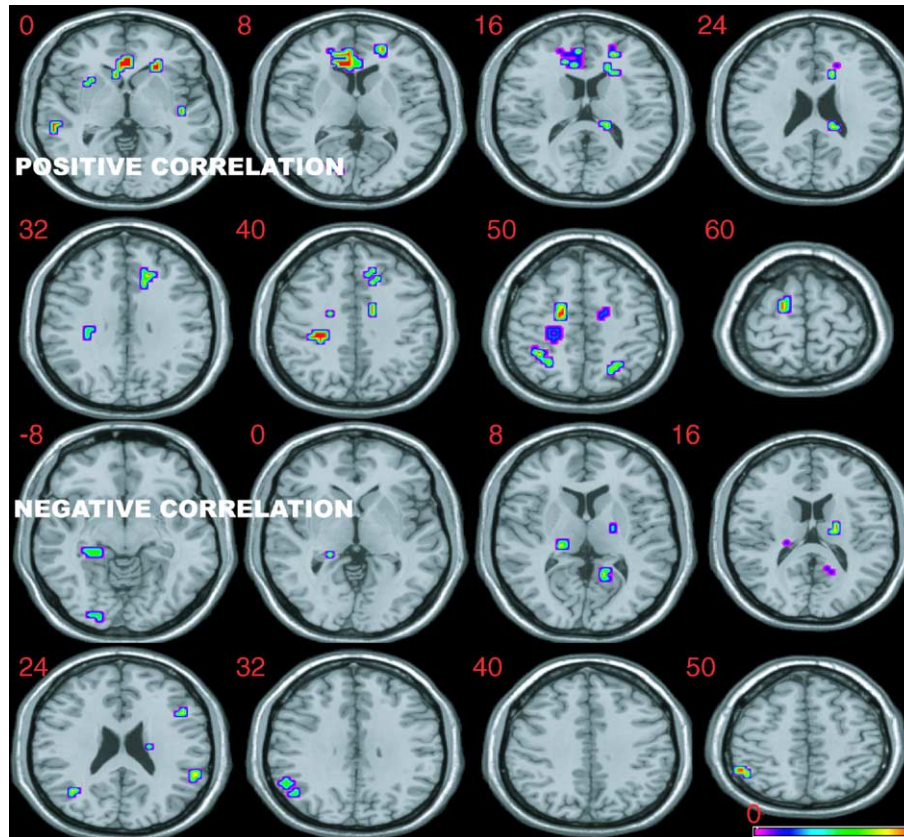


Fig. 7. Brain regions where magnitude of activation correlates with overlap on the trait task.

This region has also been found to be related to empathic judgements requiring the attribution of the emotional state of a protagonist (Farrow et al., 2001). However, this finding must be interpreted with caution as it is possible that it results from the extra verbal load in the social perception task. An additional explanation is that people attempted to lip read in some of the conditions or had a tendency for

‘silent speech’ although participants’ debriefing suggests that this was not the case.

Increased BOLD signal was also observed in somatosensory areas such as the insula and supramarginal gyrus. Adolphs et al. (2000) also found these areas to be important for emotion perception and suggested that they may be involved in the construction of a ‘covert online somatosensory’ representation. In addition, Carr et al. (2003) implicated the insula in the observation and imitation of others’ emotional expressions. Activation in the insula has previously been observed when mother’s view their own child’s face vs. a familiar face (Leibenluft et al., 2004). These findings are in line with the idea that ‘covert online somatosensory representations’ may be of use in social perception especially with stimuli that are difficult to decode, i.e. being brief and degraded in the case of the body-only clips (Adolphs et al., 2000). The activation of these areas in the current paradigm therefore suggests that a simulation strategy was adopted as opposed to one based on rules, a necessity for an empathic response.

Turning to the correlations between offline behavioural measures and brain activation, these admittedly preliminary data suggest the ACC and adjacent regions to be involved in states of self-orientated personal distress. There was increased blood flow in the ‘affective division’ of the ACC (Bush et al., 2000) in those who report high levels of personal distress. This region is thought to be involved in the contextual representation and intentional modulation of autonomic arousal (Critchley et al., 2001, 2004; Frith and Frith, 2003). It is conceivable that participants high on self-reported ‘personal distress’ had to modulate their own arousal levels to suit the task demands. In addition, the negative correlation observed between activation in this area and self-reported social skills, may provide

Table 5
Brain activation correlated with ‘self-overlap’ on the trait task

Brain region	x	y	z	No. of voxels	P value
<i>Positive correlation</i>					
Right					
Anterior cingulate (BA24)	4	37	-7	58	0.0002
Ant-mid cingulate gyrus (BA32)	14	30	26	16	0.0002
Inferior frontal gyrus (BA47)	25	33	-7	6	0.0009
Precuneus (BA7)	22	-56	42	5	0.009
Left					
Ant-mid cingulate gyrus (BA24)	-18	-4	31	15	0.0002
Middle temporal gyrus (BA21)	-51	-26	-7	10	0.0002
Supramarginal gyrus (BA40)	-32	-40	37	9	0.0002
Inferior frontal gyrus (BA47)	-29	11	-18	5	0.004
<i>Negative correlation</i>					
Right					
Superior temporal gyrus (BA37)	56	-37	15	5	0.003
Inferior frontal gyrus (BA45)	47	22	15	3	0.008
Left					
Inferior parietal lobe (BA40)	-47	-48	42	7	0.0002
Superior temporal gyrus (BA22)	-36	-56	15	3	0.008

further evidence in support of such an account. It is plausible that people who report themselves as being particularly socially skilled are less likely to find other people's negative states so personally aversive and hence have less need to regulate their own arousal. On the other hand, the need to modulate this negative arousal may in turn have a blanket effect and inhibit empathic or vicarious arousal responses, in line with the negative correlation observed. The association between longer latencies and increased self-reported personal distress is in line with this explanation.

The relationship between activation in the right inferior frontal gyrus (BA45), which is thought to contain mirror neurones (Molnar-Szakacs et al., 2005), and self-reported social skills is also consistent with a 'shared representations' account. Activity in the insula/putamen, on the other hand, was found to correlate both with social skills and personal distress. This fits with the idea that these regions are involved in the representation of online somatosensory sensations (Adolphs et al., 2000) whether covert or conscious, self- or other-orientated. Again, this is in line with a 'shared representations' strategy whether employed by people who deem themselves socially competent or those who self-report 'personal distress'.

A strong positive relationship was also observed between activation in the rostral ACC and the degree of self-overlap trait as measured by the trait task. As the association was positive, and related to an increase in self–other overlap, it is possible that this brain structure exerts its influence by providing first person knowledge as to the nature of the target mental state. Similar brain areas were found to be activated when making judgements about self-descriptive personality traits (Kircher et al., 2002), during reflection on ones own physical traits (Kjaer et al., 2002) and when making self–other judgements about the trait adjectives (Kelley et al., 2002). The supramarginal gyrus was also related to the degree of self overlap, consistent with the idea that somatosensory information is involved in providing first person knowledge (Ruby and Decety, 2004) in emotional perspective-taking (Adolphs et al., 2000).

Interestingly, the behavioural data indicated that *less* self–other overlap led to increased accuracy, in line with the idea that there is an optimal degree of reliance on first person knowledge in social perception and that a complete blurring of self and other is detrimental (Decety and Jackson, 2004; Ramnani and Miall, 2004). It seems therefore that less overlap on this task is indicative of a stronger boundary between self and other. The brain activation data support this idea as the inferior frontal gyrus (BA47) and inferior parietal lobe (BA40) were negatively associated with degree of overlap. The inferior parietal lobe has been found to be related to the *distinction* between self and other and it may be that the further recruitment of specialised neurones in the inferior frontal gyrus is reliant on this distinction. It is also of interest that activity in the rostral ACC was related to both the degree of reliance on self-concept and self-reported personal distress. This is consistent with the idea that a personal distress response is self- rather than other-orientated. These data suggest that this task may therefore provide a robust and useful offline cognitive measure of the degree of self–other overlap in paradigms which recruit the use of 'shared representations'.

The increase in BOLD signal observed in the precuneus (BA7) in the non-social labelling condition (as contrasted with social perception) is probably a result from the lack of matching for difficulty between these two tasks, as this brain area is thought to be more active during rest conditions. An alternative explanation is that this area underpins the switch in attention from one task to

another. A potential confound of this study is that constituent 'parts' of the video clips seen as body and face are again shown in the figure condition. Some of the activation observed, i.e. parahippocampal gyrus, may therefore reflect the use of recognition memory in some participants, although the use of a memory-based strategy to carry out the task would be effortful and non-intuitive.

Conclusion

These data support the idea that social perception and empathy rely on the use of 'shared representations', that is personal experience of a related state of mind. This study also suggests that it is necessary to further fractionate the concept of empathy and consider the impact of self-orientated responses such as personal distress, and the actual *degree* of overlap between representations of the self and other, both of which are integral to developing a robust, and clinically relevant account of empathy.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.neuroimage.2005.09.001.

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