

“Neurobiological bases of affective mirroring in depressed mother-infant interactions”

SCIENTIFIC REPORT

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Introduction

Maternal ability in responding to infant’s signals is based on an empathetic aptitude which considers especially the reading of his affective state. Such competencies are sustained by reflective functioning, a psychological process that allows the mother to interpret her son’s behaviour by the light of underlying mental states: this process is linked to representational models of Self and Other, which are organized on the basis of maternal infantile attachment experiences (Fonagy, 1998, 1999a,b).

Maternal depressive conditions can compromise these aspects going to influence negatively the quality of dyadic relationship. In fact, in depressive conditions maternal empathic abilities can be compromised, going to expose the infants to psychopathological risk, since the first months of life (Ammaniti et al., 2007). Depression significantly jeopardize maternal behaviors (Campbell et al., 1995), bringing to unforeseeable and incoherent relational patterns, during interactive exchanges with the infant (Carlson, Sroufe, 1995).

Depressed mothers seem to be unresponsive and emotionally unavailable, show poor imitative and mirroring behaviors during face-to-face interactions (Field, 1984; Cohn et al., 1990; Cohn, Tronick, 1983) and manifest significant difficulties in reflecting both upon their-own emotions and upon their infants’ ones. During interactions, the recurrent failures in the process of mutual affective regulation let the baby experience negative emotions and a sense of lack of connection with the others. In the attempt to face these negative emotions, the infant develops an affective core, mainly characterized by rage, sadness, and lack of trust in the mother. Moreover, by virtue of his-own adaptive abilities, the infant can structure relational models which involve an excess or deficiency in his self-regulation strategies (Ammaniti et al., 2007; Tronick, Weinberg, 1997).

At neurobiological level, empathy is relied on the activity of mirror neurons. Mirror neurons map observed and executed actions, personally experienced and observed emotions or sensations within the same neural substrate, by means of "embodied simulation" processes. By means of “embodied simulation” internal representations of the body states associated with actions, emotions, and sensations are evoked in the observer, as if he/she would be doing a similar action or experiencing a similar emotion or sensation. These functional processes enhance individuals who are confronting the behaviour of others, in experiencing a specific phenomenal state of “intentional attunement”: this condition generates a peculiar quality of familiarity with other individuals, produced by the collapse of the others' intentions and emotions into the observer's ones (Ammaniti, Trentini, 2009; Gallese, 2001, 2003a,b, 2006).

Aims

Beginning from these theoretical premises, we aimed to explore the reciprocal correspondences between psychological-representational aspects and neurobiological correlates of maternal empathy, in normal and depressive risk conditions.

Subjects

The sample consists of 30 mothers, who were divided in two groups:

- 16 mothers without any psychopathological symptoms*
- 14 mothers at risk for depression**

The mothers' children were all first-born, non-adopted infants aged between 6 and 12 months.

Exclusion criteria were 1) history of major medical illnesses, 2) ongoing medical therapy, 3) pregnancy, 4) MRI contraindications.

All the participants gave their informed consent and the study was approved by the local Ethics Committee.

***Data have been yet published (see Lenzi et al., 2009)**

****The paper is in preparation (see Lenzi et al., 2011b)**

Instruments

Psychodiagnostic assessment

- **Symptom Checklist-90-Revised** (SCL-90-R, Derogatis 1977). The SCL-90-R is a 90-items self-report symptom inventory (scores 0-4), which singles out nine symptomatic dimensions (*Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, Psychoticism*) and three Global Indices of Distress (*Global Severity Index, Positive Symptom Distress Index, Positive Symptom Total*). This tool may evidence clusters of symptoms associated with specific psychopathological conditions; furthermore, thanks to Global Indices, the SCL-90-R indicates the degree of severity and depth of individual psychological distress with respect to the nine measured primary dimensions.
- **Center for Epidemiological Studies Depression Scale** (CES-D, Radloff, 1977). The CES-D is a *self-report* 20 items questionnaire, with scores ranging between 0 and 60, which detects the depressive risk from a score equal or greater than 20 (italian validation of the instrument by Pierfederici et al., 1982).
 - The mean score of mothers without any psychopathological symptoms is 13.5 (± 4.73 , range: 3- 18).
 - The mean score of mothers at risk for depression is 29.36 (± 5.83 , range: 23-42).

Attachment models and Reflective Functioning:

- **Adult Attachment Interview** (AAI) (Main, Goldwyn, 1997). The AAI is a semi-structured, audio-taped interview, which evaluates adults' mental representations referred to attachment relationships. Adults are asked to retrieve attachment-related autobiographical memories from early childhood and to evaluate these memories and their effects from their current perspective, so that the structural dimension of the transcript, rather than its content, is coded. The coding system considers five Scales for Inferred Experiences with Parents (Loving, Rejecting, Involving/Role-reversing, Neglecting, Pressuring to achieve), nine Scales for Patterned or Organized States of Mind (Coherence of transcript, Metacognitive monitoring, Overall coherence of mind, Idealization of parent, Insistence on lack of recall, Dismissing derogation, Fear of loss, Involving/Preoccupying anger, Passivity or vagueness of discourse) and, furthermore, Scales for Unresolved/disorganized States of Mind in relation to loss or to abuse. On the basis of the scores assigned to the scales, transcripts can be classified into one of the following categories for overall state of mind: Secure/autonomous with respect to attachment (F); Dismissing of attachment (Ds); Preoccupied with or by early attachments or attachment-related experiences (E). In presence of unresolved responses respect to experiences of loss or abuse, transcripts can receive the additional classification of Unresolved/disorganized (U/d); finally, when texts cannot be fitted to any organized AAI placement, they are categorized as Cannot Classify (CC).
- **Reflective Functioning Scale** (Fonagy et al., 1998) was applied to specific AAI questions (*demand and permit questions*). *Demand questions* highlight reflective functioning and explore both the quality of the infantile attachment experience and its influence on individual development. *Permit questions* are not directly aimed at analysing an adult's metacognitive ability, but are often able to activate it, in a more creative and original manner. Reflective functioning evaluation criteria are:

awareness of mental states nature; explicit effort in extrapolating mental states underlying a specific behaviour; recognition of developmental changes of mental states; recognition of one's own and interviewer's mental states. Coders are required to notice the presence or the absence of a reflective position in relation both to self and to others, in order to assign a score on a scale from -1 (Anti-reflective functioning) to 9 (Elevated reflective functioning), with intermediate scores: 1 (Absence of reflective functioning), 3 (Low reflective functioning), 5 (Ordinary reflective functioning), 7 (High reflective functioning). By grouping the scores of the scale, Ammaniti and colleagues (1999) identified the following levels of reflective functioning:

- Low (from -1 to 3): adults display systematic resistance to reflection (-1), or use superficial levels of reflective functioning (3);
- Middle (from 4 to 6): adults show a sufficient ability to reflect upon themselves and other individuals in terms of mental states (feelings, beliefs, intentions, motivations, desires).
- High (from 7 to 9): adults show a high ability to represent themselves and other individuals in terms of mental states.

fMRI experiment

Stimuli

Each baby was videotaped during a face-to-face interaction with the mother and 36 full-face, color pictures, with eye gaze on the center, were selected. Videos were analyzed to define specific affective configurations, according to precise, coded combinations of changes observed in the forehead, nose, and mouth.

Four expressions (joy, distress, ambiguous, and neutral) were identified according to the following criteria (Oster et al., 1992):

- **Joy (J):** narrowed eyes, arched eyebrow, widened mouth with corners raised.
- **Distress (D):** brows drawn together and lowered to create a midbrow bulge; a deepened naso-labial furrow; tight squeezing of the eye orbit muscles, resulting in a strong squint; widened mouth with corners lowered (Oster et al., 1992).
- **Ambiguous (A):** blended expression, co-presence of different facial mimic patterns in the upper and lower areas of the face (Izard et al., 1983; Sullivan, Lewis, 2003).
- **Neutral (N):** brows raised slightly and eyes wide open; the mouth is relaxed with semi-opened lips, or (rarely) closed lips; naso-labial folds are absent (Izard et al., 1983; Sullivan, Lewis, 2003).

Activation Paradigm*

Before scanning, subjects were shown pictures of the unknown child to overcome the novelty effect associated with someone else's child. During scanning, the mothers were asked to perform 2 different tasks, one per session. During each session, they were instructed either to "imitate" or to "observe and empathize" with the children (2 sessions per task, counterbalanced within the group: that is, 8 mothers started the experiment with an imitation session, whereas the other 8 mothers started with an observation session). During each session, 72 pictures were presented in blocks (18 active blocks and 3 rest blocks per session). Each block comprised 4 images of the same child type and expression (one block = one condition).

**Data were acquired on a Siemens Allegra 3 Tesla head-only scanner.*

Results

Psychological testing

Mothers without psychopathological symptoms present mainly a secure state of mind with respect to attachment (N=13), with only 3 mothers presenting dismissing attachment models. These mothers report a middle level of reflective functioning (M=4, ± 1.02 , range: 3-6), showing a sufficiently articulated comprehension of their-own as well as of their children' mental states (Ammaniti et al. 1999).

In the group of mothers at risk for depression, we found 7 mothers with a secure state of mind with respect to attachment and 7 mothers with insecure attachment models (Dismissing=3; Preoccupied=2;

Cannot/Classify=2). These mothers present low level of reflective functioning ($M=3.04, \pm 1.47$, range: 1.5-6), evidencing a superficial use of reflection toward their-own as well as of their children' inner states (ibidem).

Neurobiological testing

In mothers without any psychopathological condition, fMRI results showed that mirror neurons, the anterior insula and the limbic system (MNs-I-Ls) are activated to a greater extent when the mothers are empathizing with their-own child than someone else's child, and its activity is function of the mothers' capacity to interpret the children' internal states. With respect to this last aspect, simple regression analysis revealed a positive correlation between activity in the right anterior insula during observation of all faces (vs. rest) and reflective functioning ($P < 0.003$), which supports the hypothesis that the MNs-I-Ls is activated to a greater extent in mothers with greater reflective functioning. It is important to underline that right insula is supposed to translate facial emotional expressions coded by mirror neurons in their internally felt significance. Furthermore, in these mothers we found that imitating the joyous expression of an infant greatly activates right limbic and temporal areas, whereas observing ambiguous expressions greatly activates areas in the left hemisphere, which is involved in higher cognitive and motor control.

In mothers at risk for depression, fMRI results show a lower activation of MNs-I-Ls, both during imitating and empathizing with the children' affective facial expressions. Furthermore, only frontal areas are activated to a greater extent when the mothers are empathizing with their-own child than someone else's child: such results put in evidence a poorer affective discrimination between their-own child's emotions and those of the unfamiliar child. Such aspects are confirmed by the lower activation observed in these mothers in the precuneus (bilaterally) when empathizing with the affective expressions of their-own child. It is remarkable that this cerebral area is supposed to be implicated in attentive processes, playing a significant role during the decoding of others' affective emotions.

Conclusion

On the basis of these empirical evidences, it could be suggested that, in normal conditions, mirror neurons represent the neurobiological substrate of maternal empathy, facilitating the dyadic exchanges during the first year of the baby, in a developmental stage when language has not developed yet. Such aspects are sustained by mothers' ability to reflect upon their-own child's mental states (namely, intentions, emotions, thoughts and desires).

As we have already put in evidence, such competencies are linked to representational models of Self and Other, which are organized on the basis of maternal infantile attachment experiences. With respect to this considerations, in a recent study we evidenced how secure attachment models, compared to insecure models (in particular dismissing ones) improve the activity of cerebral areas implicated in empathy and emotions, leading to greater women' empathic response toward infant's emotions and greater activation of neural circuitry implicated in nurturing behaviours (Lenzi et al., 2011).

To date, the neurobiological investigation of maternal empathic abilities is not yet well developed, especially in the field of parental psychopathology. The results of our studies represent a first step in the understanding of the cerebral processes which could be involved in the reduction of maternal empathic abilities in depressive risk conditions.

Scientific products of the project

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