INTENTIONAL ATTUNEMENT: MIRROR NEURONS AND THE NEURAL UNDERPINNINGS OF INTERPERSONAL RELATIONS

The neural circuits activated in a person carrying out actions, expressing emotions, and experiencing sensations are activated also, automatically via a mirror neuron system, in the observer of those actions, emotions, and sensations. It is proposed that this finding of shared activation suggests a functional mechanism of "embodied simulation" that consists of the automatic, unconscious, and noninferential simulation in the observer of actions, emotions, and sensations carried out and experienced by the observed. It is proposed also that the shared neural activation pattern and the accompanying embodied simulation constitute a fundamental biological basis for understanding another's mind. The implications of this perspective for psychoanalysis are discussed, particularly regarding unconscious communication, projective identification, attunement, empathy, autism, therapeutic action, and transference-countertransference interactions.

From the *Project* on, Freud (1895) had an abiding interest in understanding the biological foundations of the psychological processes and phenomena with which psychoanalysis is concerned. Given the limited state of knowledge and technologies at the time, the *Project* could not be carried very far. Advances in knowledge and technology in recent years, however, have led to a resumption of the aims of the

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Project and have resulted in an increasingly active dialogue between neuroscience and psychoanalysis. We hope to contribute to that dialogue by relating recent advances in neuroscience, in particular the discovery of mirror neurons (Gallese et al. 1996; Rizzolatti et al. 1996), to issues having to do with our "mind-reading" ability, that is, how one understands the mental states of another. We will try to demonstrate the relevance of the mirror neuron discovery and related findings, as well as the theory of "embodied simulation" (Gallese 2001, 2003a,c, 2005a,b, 2006), to infant-mother interaction, certain aspects of psychoanalytic theory and practice, and a number of psychoanalytic concepts including empathic understanding, identification, projective identification, and transference-countertransference interactions.

Our plan in this paper is as follows: we will first describe the recent discovery of a mirror neuron system for action in both monkeys and humans. We will then present evidence also indicating the existence of mirroring neuronal systems for "reading" another's intentions, linguistic expressions, emotions, and somatic sensations. The evidence, we argue, points to neuronal mechanisms whereby the observation of another triggers an automatic and unconscious "embodied simulation" of that other's actions, intentions, emotions, and sensations. Embodied simulation, we argue further, constitutes a fundamental functional mechanism for empathy and, more generally, for understanding another's mind.

THE MIRROR NEURON SYSTEM FOR ACTION IN MONKEYS AND HUMANS: EMPIRICAL EVIDENCE

The Mirror Neuron System in Macaque Monkeys

In the early 1990s a new class of premotor neurons was discovered in the macaque monkey brain. These neurons discharge not only when the monkey executes goal-related hand actions like grasping objects, but also when it observes other individuals (monkeys or humans) executing similar actions. They were called *mirror neurons* (Gallese et al. 1996; Rizzolatti et al. 1996).[1] Neurons with similar properties were

[1]This paper is focused exclusively on the relationship among the mirror neuron system, embodied simulation, and the experiential aspects of intersubjectivity. For the sake of concision, many other issues related to mirror neurons and simulation will not be addressed here. The vast literature on the mirror neuron system in humans and its relevance for theory of mind, imitation, and the evolution of language is reviewed and discussed in several papers (Gallese and Goldman 1998; Rizzolatti and Arbib 1998; Gallese 2003a; Metzinger and Gallese 2003; Rizzolatti and Craighero

later discovered in a sector of the posterior parietal cortex reciprocally connected with area F5 (parietal mirror neurons; see Rizzolatti, Fogassi, and Gallese 2001; Gallese et al. 2002).

The mere observation of an object-related hand action occasions in the observer an automatic activation of the same neural network active in the person performing the action. It has been proposed that this mechanism could be at the basis of a direct form of action understanding (Gallese et al. 1996; Rizzolatti et al. 1996; see also Gallese 2000, 2001, 2003a,c, 2005a,b, 2006; Gallese et al. 2004; Rizzolatti, Fogassi, and Gallese 2001, 2004; Rizzolatti and Craighero 2004). It must be stressed that the activation of mirror neurons is not a duplication of the action goal, putatively detected somewhere upstream of the premotor cortex. When mirror neurons fire, during both action execution and observation, they directly specify the goal. In fact, recent evidence shows that grasping-related F5 neurons (among which are mirror neurons) code the goal of a given motor act, like grasping an object, regardless of the movements required to accomplish it (Escola et al. 2004; Umiltà et al. 2006).

Further studies carried out by the same group of researchers at the Department of Neuroscience of the University of Parma corroborated and extended the original hypothesis. It was shown that F5 mirror neurons are activated also when the final critical part of the observed action, that is, the hand-object interaction, is hidden (Umiltà et al. 2001). A second study showed that a particular class of F5 mirror neurons, *audiovisual mirror neurons,* can be driven not only by action execution and observation, but also by the sound produced by the action (Kohler et al. 2002).

In another study, the most lateral part of area F5 was explored where a population of mirror neurons related to the execution/observation of mouth actions was described (Ferrari et al. 2003). The majority of these neurons discharge when the monkey executes and observes transitive, object-related ingestive actions, such as grasping, biting, or licking. However, a small percentage of mouth-related mirror neurons discharge during the observation of intransitive, communicative facial actions performed by the experimenter in front of the monkey (*communicative mirror neurons*; Ferrari et al. 2003). Thus, mirror neurons seem

2004; Rizzolatti, Fogassi, and Gallese 2004; Gallese, Keysers, and Rizzolatti 2004). For an analysis of the role played by embodied simulation in conceptual structure and content, see Gallese and Lakoff (2005).

to underpin monkeys' social facial communication, and monkeys may exploit the mirror neuron system to optimize their social interactions; this is aided by the fact that audiovisual mirror neurons can be driven not only by action execution and observation but also by the sound produced by the action (Kohler et al. 2002). It has recently been shown that the observation and hearing of noisy eating actions facilitates eating behavior in pigtailed macaque monkeys (*Macaca nemestrina;* Ferrari et al. 2005). Another recent study has shown that pigtailed macaque monkeys recognize when they are imitated by a human experimenter (Paukner et al. 2005). This study shows that macaque monkeys have the capacity to discriminate between very similar goal-related actions on the basis of their degree of similarity with goal-related actions the monkeys themselves have just executed. This capacity appears to be cognitively sophisticated, because it implies a certain degree of meta-cognition in the domain of purposeful actions.

The Mirror Neuron System in Humans

Several studies using different experimental methodologies and techniques have demonstrated the existence in the human brain of a mirror neuron system matching action perception and execution. During action observation there is a strong activation of premotor and parietal areas, the likely human homologue of the monkey areas in which mirror neurons were originally described (for a review, see Rizzolatti, Fogassi, and Gallese 2001; Gallese 2003a; Rizzolatti and Craighero 2004; Gallese, Keysers, and Rizzolatti 2004). Further, the mirror neuron matching system for actions in humans is somatotopically organized, with distinct cortical regions within the premotor and posterior parietal cortices being activated by the observation/execution of mouth-, hand-, and foot-related actions (Buccino et al. 2001). It has also been shown that the mirror neuron system in humans is directly involved in imitation of simple finger movements (Iacoboni et al. 1999), as well as in learning complex motor acts without practice (Buccino, Vogt, et al. 2004).

A recent brain-imaging study, in which human participants observed communicative mouth actions performed by humans, monkeys, and dogs, showed that the observation of communicative mouth actions led to the activation of different cortical foci according to the species observed. Observation of human silent speech activated the pars opercularis of the left inferior frontal gyrus, a sector of Broca's

region. Observation of monkey lip-smacking activated a smaller part of the same region bilaterally. Finally, observation of a barking dog activated only extrastriate visual areas. Actions belonging to the motor repertoire of the observer (e.g., biting and speech reading) or very closely related to it (e.g., the monkey's lip-smacking) are mapped on the observer's motor system. Actions that do not belong to this repertoire (e.g., barking) are mapped and henceforth categorized on the basis of their visual properties only (Buccino, Lui, et al. 2004). In addition, Watkins, Strafella, and Paus (2003) showed that the mere observation of communicative, speech-related mouth actions facilitates excitability of the motor system involved in production of the same actions.

Fadiga et al. (1995) reported that when subjects observed the experimenter grasping an object, or performing aimless movements with his arm, motor evoked potentials from the hand muscles of the observer induced by the Transcranic Magnetic Stimulation (TMS) of the observer's motor cortex markedly increased relative to other control conditions (e.g., observing a fixation point on a computer screen). Further, enhancement of the motor evoked potentials occurred only in those muscles that subjects would use were they actively performing the observed movements.

Action Intention

When an individual starts a movement meant to attain a goal, such as picking up a pen, he or she has clearly in mind what he or she is going to do (e.g., write a note on a piece of paper). In this simple sequence of motor acts the final goal of the whole action is present in the agent's mind and is somehow reflected in each motor act of the sequence. The action intention, therefore, is set before the beginning of the movements. This means that when we are going to execute a given action we can predict its consequences. But a given action can be originated by very different intentions. Suppose one sees someone else grasping a cup. Mirror neurons for grasping will most likely be activated in the observer's brain. The direct matching between the observed action and its motor representation in the observer's brain, however, can tell us only what the action is (it's a grasp) and not why the action occurred. This has led some authors to argue against the relevance of mirror neurons for social cognition and, in particular, for determining the social and communicative intentions of others (see, e.g., Jacob and Jeannerod 2004; Csibra 2004).

But what is an action intention? Determining why action A (grasping the cup) was executed, that is, determining its intention, can be equivalent to detecting the goal of the still not executed and impending subsequent action (say, drinking from the cup). In a recently published functional Magnetic Resonance Imaging (fMRI) study (Iacoboni et al. 2005), these issues were experimentally addressed. Subjects watched three kinds of stimuli: grasping hand actions without a context; context only (a scene containing objects); and grasping hand actions embedded in contexts. In the last condition, the context suggested the intention associated with the grasping action (either drinking or cleaning up). Actions embedded in contexts, compared with the other two conditions, yielded a significant signal increase in the posterior part of the inferior frontal gyrus and the adjacent sector of the ventral premotor cortex where hand actions are represented. Thus, premotor mirror areas—areas active during the execution and observation of an action, previously thought to be involved only in action recognition—are actually involved as well in understanding the "why" of action, that is, the intention promoting it. Another interesting result of this study is that it makes no difference, in terms of activation of the premotor mirror areas, whether or not one is explicitly instructed to determine the intention of the observed actions of others. This means that—at least for simple actions such as those employed in this study—the ascription of intentions occurs by default, underpinned by mandatory activation of an embodied simulation mechanism.

The neurophysiological mechanism at the basis of the relationship between intention detection and action prediction was recently clarified. Fogassi et al. (2005) described a class of parietal mirror neurons whose discharge during the observation of an act (e.g., grasping an object) is conditioned by the type of not yet observed subsequent act (e.g., bringing the object to the mouth) specifying the overall action intention. This study shows that the inferior parietal lobe of the monkey contains mirror neurons discharging differentially in association with monkey motor acts (grasping) only when they are embedded in a specific goal-directed action. For example, a given neuron discharges when the monkey grasps an object only if the grasping act is aimed at bringing the object into the mouth and not if the intention is to place it into a cup. It appears therefore that these neurons code the same motor act differently depending on the distal, overarching action goal. Single motor acts are dependent on each other as they participate to the overarching distal goal

of an action, thus forming prewired intentional chains in which each next motor act is facilitated by the previously executed one.

The visual response of many of these parietal mirror neurons is similar to their motor response. In fact, they discharge differentially depending on whether the observed grasping is followed by bringing the grasped object to the mouth or by placing it into a cup. It must be noted that the neurons discharge *before* the monkey observes the experimenter starting the second motor act (bringing the object to the mouth or placing it in the cup). This new property of parietal mirror neurons suggests that in addition to recognizing the goal of the observed motor act, they discriminate identical motor acts according to the action in which these acts are embedded. Thus, these neurons not only code the observed motor act but also seem to allow the observing monkey to predict the agent's next action, and henceforth the overall intention. It is possible to interpret this mechanism as the neural correlate of the dawning of some of the sophisticated mentalizing abilities characterizing our species.

The mechanism of intention understanding just described appears to be rather simple: depending on which motor chain is activated, the observer is going to activate the motor schema of what, most likely, the agent is going to do. How can such a mechanism be formed? At present we can only speculate. It can be hypothesized that the statistical detection of what actions most frequently follow other actions, as they are habitually performed or observed in the social environment, can constrain preferential paths chaining together different motor schemata. At the neural level this can be accomplished by the chaining of different populations of mirror neurons coding not only the observed motor act but also those that in a given context would normally follow.

Ascribing simple intentions would therefore consist in predicting a forthcoming new goal. According to this perspective, action prediction and the ascription of intentions are related phenomena, underpinned by the same functional mechanism, embodied simulation. In contrast with what mainstream cognitive science would maintain, action prediction and the ascription of intentions—at least of simple intentions—do not appear to belong to different cognitive realms; rather, both pertain to embodied simulation mechanisms underpinned by the activation of chains of logically related mirror neurons.

Language and Embodied Simulation

Any account of human intersubjectivity cannot get away from language, because language is the most specific hallmark of what it means to be human. Human language for most of its history has been just spoken language. This may suggest that language most likely evolved in order to provide individuals a more powerful and flexible social cognitive tool with which to share, communicate, and exchange knowledge (see Tomasello et al. 2005). What is the relationship between the motor system, embodied simulation, and language comprehension? The meaning of a sentence, regardless of its content, has been classically considered to be understood by relying on symbolic, amodal mental representations (Pylyshyn 1984; Fodor 1998). An alternative hypothesis, now more than thirty years old, assumes that the understanding of language relies on "embodiment" (Lakoff and Johnson 1980, 1999; Lakoff 1987; Glenberg 1997; Barsalou 1999; Pulvermüller 1999, 2002, 2005; Glenberg and Robertson 2000; Gallese 2003b; Feldman and Naranayan 2004; Gallese and Lakoff 2005).

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According to the embodiment theory, for action-related sentences the neural structures presiding over action execution should also play a role in understanding the semantic content of the same actions when verbally described. Empirical evidence shows this to be the case. Glenberg and Kaschak (2002) asked participants to judge if a read sentence was sensible or nonsense by moving their hand to a button requiring movement away from the body (in one condition) or toward the body (in the other condition). Half of the sensible sentences described action toward the reader and half away. Readers responded faster to sentences describing actions whose direction was congruent with the required response movement. This clearly shows that action contributes to sentence comprehension.

The most surprising result of this study, though, was that the same interaction between sentence movement direction and response direction was also found with abstract sentences describing transfer of information from one person to another, such as "Liz told you the story" vs. "You told Liz the story." This result extends the role of action simulation to the understanding of sentences describing abstract situations. Similar results have recently been published by other authors (Borghi, Glenberg, and Kaschak 2004; Matlock 2004).

A prediction of the embodiment theory of language understanding is that when individuals listen to action-related sentences, their mirror

neuron system will be modulated. The effect of this modulation should influence the excitability of the primary motor cortex, and hence the production of the movements it controls. To test this hypothesis two experiments were carried out (Buccino et al. 2005). In the first experiment, by means of single pulse TMS, either the hand or the foot/leg motor areas in the left hemisphere were stimulated in distinct experimental sessions, while participants were listening to sentences expressing hand and foot actions. Listening to abstract content sentences served as a control. Motor evoked potentials (MEPs) were recorded from hand and foot muscles. Results showed that MEPs recorded from hand muscles were specifically modulated by listening to hand action–related sentences, as were MEPs recorded from foot muscles by listening to foot action–related sentences.

In the second behavioral experiment, participants had to respond with the hand or the foot while listening to sentences expressing hand and foot actions, as compared to abstract sentences. Coherently with the results obtained with TMS, reaction times of the two effectors were specifically modulated by the effector-congruent heard sentences. These data show that listening to sentences describing actions activates different sectors of the motor system, depending on the effector used in the action described.

Several brain-imaging studies have shown that processing linguistic material in order to retrieve its meaning activates regions of the motor system congruent with the processed semantic content. Hauk, Johnsrude, and Pulvermüller (2004) showed in an event-related fMRI study that silent reading of words referring to face, arm, or leg actions led to the activation of different sectors of the premotor-motor areas congruent with the referential meaning of the read action words. Tettamanti et al. (2005) showed that listening to sentences expressing actions performed with the mouth, the hand, and the foot produces activation of different sectors of the premotor cortex, depending on the effector used in a given sentence. These activated sectors correspond, though only coarsely, with those active during the observation of hand, mouth, and foot actions (Buccino et al. 2001).

These data support the notion that the mirror neuron system is involved not only in understanding visually presented actions, but also in mapping acoustically presented action-related sentences. The precise functional relevance of the involvement of action embodied simulation for language understanding remains unclear. One could speculate

that such an involvement is purely parasitic, or at best reflects motor imagery induced by the understanding process upstream. Studying the spatiotemporal dynamic of language processing becomes crucial in settling this issue. Evoked Readiness Potential (ERP) experiments on silent reading of face-, arm-, and leg-related words showed category-specific differential activations ~200 ms after word onset. Distributed source localization performed on stimulus-triggered ERPs showed different somatotopically arranged activation sources, with a strongest inferior frontal source for face-related words and a maximal superior central source for leg-related words (Pulvermüller, Härle, and Hummel 2000).

This dissociation in brain activity patterns supports the idea of stimulus-triggered early lexicosemantic processes taking place within the premotor cortex. Pulvermüller, Shtyrov, and Ilmoniemi (2003) used Magneto-Encephalography (MEG) to investigate the time course of cortical activation underlying the magnetic mismatch negativity elicited by hearing a spoken action-related word. The results showed that auditory areas of the left superior-temporal lobe became active 136 ms after the information in the acoustic input was sufficient for identifying the word, and activation of the left inferior-frontal cortex followed after an additional delay of 22 ms.

In sum, although these results are far from being conclusive on the effective relevance of the embodied simulation of action for language understanding, they show that simulation is specific and automatic and that it has a temporal dynamic compatible with such a function. More studies will be required to validate what at present seems a very plausible hypothesis, and to extend it to linguistic expressions of abstract content.

MIRRORING EMOTIONS AND SENSATIONS BY MEANS OF EMBODIED SIMULATION

Emotions constitute one of the earliest ways available to the individual for acquiring knowledge about its situation, thus enabling a reorganization of this knowledge on the basis of the outcome of the relations entertained with others. The coordinated activity of sensorimotor and affective neural systems results in simplification and automatization of the behavioral responses living organisms are supposed to produce in order to survive. The integrity of the sensorimotor system indeed

appears critical for the recognition of emotions displayed by others (see Adolphs 2003; Adolphs et al. 2000), because, in line with a proposal originally advanced by Damasio (1994, 1999), the sensorimotor system appears to support the reconstruction of what it would feel like to be in a particular emotion, by means of simulation of the related body state. The implication of this process for empathy should be obvious.

A recent fMRI study showed that experiencing disgust and witnessing the same emotion expressed by the facial mimicry of someone else both activate the same neural structure—the anterior insula—at the same overlapping location (Wicker et al. 2003). This suggests, at least for the emotion of disgust, that the first- and third-person experiences of a given emotion are underpinned by the activity of a shared neural substrate.

There is evidence that a process parallel to the observation of motor actions occurs when observing another's emotional facial expression. For example, when people observe pictures of emotional facial expressions, they show spontaneous and rapid electromyographic responses in the facial muscles that correspond to the facial muscles involved in the observed person's facial expressions. Observations of pictures of happy faces evoke increased zygomatic major muscle activity in the observer, while observation of angry faces evokes increased corrugator supercilii muscle activity—the same muscle areas involved in, respectively, happy and angry facial expressions (Dimberg 1982; Dimberg and Thunberg 1998; Dimberg, Thunberg, and Emehed 2000; Lundqvist and Dimberg 1995).

Let us focus now on somatic sensations as the target of our social perception. As repeatedly emphasized by phenomenology, touch has a privileged status in making possible the social attribution of lived personhood to others. "Let's be in touch" is a common utterance in everyday language, which metaphorically describes the wish of being in contact with someone else. Such examples show how the tactile dimension can be intimately related to the interpersonal dimension.

As predicted by the "shared manifold hypothesis" (Gallese 2001, 2003a,c, 2005a,b), empirical evidence suggests that the first-person experience of being touched on one's body activates the same neural networks activated by observing the body of someone else being touched (Keysers et al. 2004; Blakemore et al. 2005). This double pattern of activation of the same somatosensory-related brain regions suggests that our capacity to experience and directly understand the tactile experience of others

could be mediated by embodied simulation, that is, by the externally triggered activation of some of the same neural networks underpinning our own tactile sensations. The study by Blakemore et al. (2005) actually shows that the degree of activation of the same somatosensory areas activated during both the subjective tactile experience and its observation in others could be an important mechanism enabling the subject to disentangle who is being touched. In fact, what this study shows is that the difference between empathizing with someone else's tactile sensation and actually feeling the same sensation on one's body (as in the case of synaesthesia) is a matter of degrees of activation of the same brain areas. These data support the notion that disentangling who is who (self vs. observer) does not pose a problem for the shared manifold hypothesis.

A similar embodied simulation mechanism likely underpins our experience of the painful sensations of others. Single neuron recording experiments carried out in awake neurosurgical patients (Hutchison et al. 1999), as well as experiments using fMRI (Singer et al. 2004; Morrison et al. 2004; Jackson, Meltzoff, and Decety 2005; Botvinick et al. 2005) and TMS (Avenanti et al. 2005) with healthy subjects, all show that the same neural structures are activated both during the subjective experience of pain and in the direct observation or symbolically mediated knowledge of someone else's experience of the same painful sensation.

It should be noted that the fMRI and TMS studies show that the overlap of activation in the self/other experience conditions can be modulated in terms of the brain areas involved by the cognitive demands imposed by the type of tasks. When subjects are required to simply watch the painful stimulation of a body part experienced by some stranger, the observer extracts the basic sensory qualities of the pain experienced by others, mapping it somatotopically onto his or her own sensorimotor system. However, when subjects are required to imagine the pain suffered by their partner out of their sight, only brain areas mediating the affective quality of pain (the anterior cingulate cortex and the anterior insula) are activated. It has been convincingly argued (Singer and Frith 2005) that the particular mental attitude of individuals could be the key variable determining the degree and quality of the activation of shared neural circuits when experiencing the sensations of others, as in the case of pain.

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Embodied Simulation

We want first to distinguish between "standard simulation" theory (Gordon 1986, 1995, 1996, 2005; Harris 1989; Goldman 1989, 1992a,b, 1993a,b, 2000, 2005) and "embodied simulation." According to the former, the observer adopts the other's perspective, imaginatively generates "pretend" mental states (desires, preferences, beliefs), and then infers the other's mental states. As Gordon and Cruz (2004) put it in their description of simulation theory, "One represents the mental activities and processes of others by mental simulation, i.e., by generating similar activities and processes in oneself. . . . One imaginatively adopts the circumstances of the target and then uses one's own mental apparatus to generate mental states and decisions" (pp. 1–2). Or, as Jung (2003) describes the theory, "Simulation requires the subject to empathize, that is, 'to put himself in the shoes of the other,' that is, to pretend to receive the same sensory inputs, engage the same processes that the subject would engage in the same situation and predict the behavior based on *what the subject* himself would do" (p. 215). It is just such hypothesized intervening inferential processes that are called into question in Gallese's theory of embodied simulation (2003a,c, 2005a,b, 2006). This theory rejects both the theory-theory account[2] and standard forms of simulation theory that depend primarily on explicit simulations of the other's internal state and that require explicitly taking the perspective of the other, by relying on introspection.

Here we employ the term *embodied simulation* as a mandatory, nonconscious, and prereflexive mechanism that is not the result of a deliberate and conscious cognitive effort aimed at interpreting the intentions hidden in the overt behavior of others, as implied by the theory-theory account. We believe that embodied simulation is a prior functional mechanism of our brain. However, because it also generates representational content, the functional mechanism seems to play a major role in our epistemic approach to the world. It uses the outcome of simulated actions, emotions, or sensations to attribute this outcome to another organism as a real goal-state it is trying to bring about, or as a real emotion or sensation it is experiencing.

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[2]According to the theory-theory perspective (e.g., Carruthers and Smith 1996), our understanding of another's mind is based on a theory that accounts for people's behavior in terms of folk psychology concepts such as beliefs and desires, by relying on abstract symbolic representations in propositional format.

When we see the facial expression of someone else, and this perception leads us to experience that expression as a particular affective state, we do not accomplish this type of understanding through an argument by analogy. The other's emotion is constituted, experienced, and therefore directly understood by means of an embodied simulation producing a shared body state. It is the activation of a neural mechanism shared by the observer and the observed that enables experiential understanding. A similar simulation-based mechanism has been proposed by Goldman and Sripada (2004) as "unmediated resonance."

In all of the above domains—of actions, intentions, emotions, and sensations—perceiving the other's behavior automatically activates in the observer the same motor program that underlies the behavior being observed. That is, one internally simulates the observed behavior, automatically establishing a direct experiential line between observer and observed in that in both the same neural substrate is activated. Although we may and do employ more explicit hermeneutic strategies and arguments by analogy to understand another, embodied simulation—we propose—constitutes a fundamental basis for an automatic, unconscious, and noninferential understanding of another's actions, intentions, emotions, sensations, and perhaps even linguistic expressions. According to our hypothesis, such body-related experiential knowledge enables a direct grasping of the sense of the actions performed by others, and of the emotions and sensations they experience.[3]

According to this hypothesis, when we confront the intentional behavior of others, embodied simulation, a specific mechanism by means of which our brain/body system models its interactions with the world, generates a specific phenomenal state of "intentional attunement." This phenomenal state in turn generates a peculiar quality of familiarity with other individuals. The different mirror neuron systems represent its subpersonal instantiations. By means of embodied simulation we do not just "see" an action, an emotion, or a sensation. Side by side with the sensory description of the observed social stimuli, internal

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[3]As Merleau-Ponty (1945) writes in *Phenomenology of Perception,* "The communication or comprehension of gestures come about through the reciprocity of my intentions and the gestures of others, of my gestures and intentions discernible in the conduct of other people. It is as if the other person's intention inhabited my body and mine his" (p. 185); "We are saying that the body, in so far as it has 'behavior patterns', is that strange object which uses its own parts as a general system of symbols for the world, and through which we can consequently 'be at home' in that world, 'understand' it and find significance in it" (p. 237).

representations of the body states associated with these actions, emotions, and sensations are evoked in the observer, "as if" he or she were doing a similar action or experiencing a similar emotion or sensation.

Implications for Infant Development

The seminal study of Meltzoff and Moore (1977) and the subsequent research field it opened (see Meltzoff and Moore 1997, 1998; Meltzoff 2002) showed that newborns as young as eighteen hours are capable of reproducing mouth and face movements displayed by the adult they are facing. That particular part of their body replies, though not in a reflex-like way (Meltzoff and Moore 1977, 1994), to movements displayed by the equivalent body part of someone else. More precisely, this means that newborns set into motion, and in the "correct" way, a part of their body they have no visual access to, but that nevertheless matches an observed behavior. To put it crudely, visual information is transformed into motor information. This apparently innate mechanism has been referred to as "active intermodal mapping" (AIM; see Meltzoff and Moore 1997). Intermodal mapping defines a "supramodal actual space" (Meltzoff 2002) that provides representational frames not constrained by any particular mode of interaction, be it visual, auditory, or motor. Modes of interaction as diverse as seeing, hearing, or doing something must therefore share some peculiar feature making the process of equivalence carried out by AIM possible. The issue then consists in clarifying the nature of this peculiar feature and the possible underlying mechanisms.

The capacity of a young infant to reproduce mouth and face movements of adults is surely not based on any inferential process. It suggests, rather, the existence of shared neural networks and of a sensorimotor neural mechanism of automatic embodied simulation that is present from birth on. It also suggests a neural basis for an intersubjective process that begins early in life and is expressed in mutually coordinated activities during which the movements, facial expressions, and voice interactions of infant and mother synchronize in time (Reddy et al. 1997). This intersubjective process, we suggest, instantiates Winnicott's conception of the "mirror-role" of mother and family in child development (1967) and Stern's concept of "affective attunement" (1985). We also suggest that this intersubjective process that begins in infancy normally continues in elaborated and developed ways throughout the life span of the individual in his or her interpersonal interactions.

A further proof of the crucial relationship between embodied simulation and the development of mentalizing abilities is the recent discovery that twelve-month-old infants develop the capacity to anticipate the goal of the observed motor acts done by others only when they become able to perform the same goal-directed motor acts themselves (Sommerville and Woodward 2005; Falck-Ytter, Gredeback, and von Hofsten 2006). These results show that social cognitive skills, like action goal detection, depend on experiential knowledge gained through the parallel development of motor skills.

IMPLICATIONS FOR PSYCHOANALYSIS

It would be indeed very surprising if the findings and debate regarding the basis of our mind-reading ability did not have implications for psychoanalysis, insofar as the attempt to understand another's mind is at the heart of the psychoanalytic enterprise.

We turn now to possible implications for psychoanalysis. We will try to demonstrate that the findings and the theory of embodied simulation presented in this paper suggest the neural underpinnings of a number of psychoanalytic ideas and formulations, such as unconscious communication, projective identification, empathic understanding, and therapeutic process.

Unconscious Communication, the Mirror System, and Embodied Simulation

Freud (1912) recognized the role of communication between the analyst's and the patient's unconscious in the analytic situation. He wrote that the analyst "must turn his own unconscious like a receptive organ towards the transmitting unconscious of the patient" (p. 111). Freud did not attempt to specify the nature of the process or processes through which such unconscious communication could occur. Although he flirted with the idea of mental telepathy (Freud 1921), surely this would not serve as an adequate explanation. What, then, might these processes be? One possible mechanism, we would suggest, lies in the shared neural activation and embodied simulation we have discussed.

Both patient and analyst may be unconsciously picking up and responding to subtle cues from the other, and the perception of these cues may activate neural patterns shared by both. This process may occur repeatedly in a circular and reciprocal fashion and may constitute the basis for the unconscious communication referred to by Freud.

Although undoubtedly difficult and complex, in principle this is a researchable hypothesis.

Projective Identification

As is well known, the concept of projective identification has become widely used in contemporary psychoanalysis—although it has often been defined and employed rather loosely in a variety of different ways. The question we address here concerns the implications of the mirror neuron discovery, related findings, and the theory of embodied simulation for the concept of projective identification. Before we address that question however, given the frequent vague use of the term, we will first attempt to clarify how we understand the concept (see Migone 1995a, pp. 324–329; 1995b).

We follow Ogden's formulation (1982) in conceptualizing projective identification in terms of three steps. Step 1 consists in person A (e.g., the patient) projecting an unwanted aspect in his or her self onto person B (e.g., the analyst). According to traditional psychoanalytic theory, this means that A is likely to experience B in accord with the former's projection. For example, if A projects a hostile wish or a critical aspect of him- or herself onto B, then A is likely to attribute hostility or criticality to B and experience him or her in accord with that attribution. Thus far, this is no different from ordinary projection and is largely an intrapsychic matter. That is, A's projection onto B can occur entirely in fantasy, without an actual interaction with B and without B's physical presence. (Indeed, in Melanie Klein's original formulation, projective identification is entirely an intrapsychic phenomenon.)

Step 2, which Ogden refers to as "interpersonal pressure," entails the interpersonal factor of A inducing a reaction in B that is congruent with A's projection. For example, following the projection of a critical part of him- or herself onto the analyst, the patient may induce the latter to feel and behave critically. This step is at times described in the psychoanalytic literature in near mystical terms, with little or no attention paid to the process by which A induces B to feel and behave in accord with A's projection. However, one induces another to feel and behave in a particular way not through magical means, but by emitting certain cues, however subtle—that is, by behaving and interacting in a particular way. Thus, one may induce someone to feel critical and behave in a critical manner by being nasty, by behaving that way oneself, or by masochistically inviting criticisms. It will be noted that step 2

involves an interpersonal process and is not primarily an intrapsychic one. It should also be noted that insofar as A is successful in inducing B to feel and behave in accord with the former's projection, the projection is now supported in reality. A can feel that he or she is being realistic rather than crazy in attributing certain feelings or impulses to B. Finally, it should be noted that step 2 is often described in terms of B's "introjective identification" with A's projection; this has also been called "projective counteridentification," a term coined by Grinberg (1957, 1979), although the process we have described does not seem to entail identification in any obvious way.

Step 3 concerns how B deals with A's projection and "interpersonal pressure" and its impact on A. B's modulated and tempered reaction, according to Ogden (and others), is therapeutic because it "metabolizes" or "digests" A's projection. This permits A to reinternalize the projection, now, however, in tamed, "metabolized," and acceptable form. It seems to us that the evocative but somewhat jargony terms *metabolizes* and *digests* can be largely understood in terms of such ordinary processes as A's modeling the ways in which B reacts to A's projection and "interpersonal pressure"— that is, how B deals with affects and feelings that A finds unacceptable and unmanageable.

We can now return to the question of the implications of mirror neurons and related findings, as well as the theory of embodied simulation, for the concept of projective identification. As discussed earlier, there is evidence that experiencing an emotion and observing the same emotion expressed by another activate the same neural structure. There is also evidence that when people observe pictures of emotional facial expressions, they show rapid and spontaneous electromyographic responses in the facial muscles that correspond to the facial muscles involved in the observed person's expression. Also, as Ekman (1993, 1998; Ekman and Davidson 1994) has found, simulation of another's emotional facial expression is accompanied by the experience of a small dose of the emotion simulated.

Applying the above findings to the clinical situation leads to the following plausible formulation: It is possible that the patient's emotional tone and expressions trigger in the therapist an automatic simulation and consequently the experience of at least a small dose of an emotion similar to the one experienced by the patient. What is to be especially noted here is that according to the theory of embodied simulation and related findings, the therapist is likely to experience feelings

and emotions similar to the patient's quite apart from questions of the patient's projections and quite apart from the patient's interpersonal pressure (i.e., the patient's unconscious attempts to induce certain emotions in the therapist). Although interpersonal pressure may intensify this process, the findings reported here suggest that the process is an automatic and ubiquitous one that occurs independently of projective identification, at least as defined by Ogden. In the psychoanalytic context, this is roughly equivalent to saying that "concordant identification" (Racker 1968), independent of projection and interpersonal pressure, is a ubiquitous and automatic process in therapeutic and other interactions. Based on the mirror neuron phenomenon and related findings, one can say that in virtually any interpersonal interaction there is an automatic unconscious "induction" in each participant of what the other is feeling. This would be true for both patient and analyst.

There is no reason to expect that the therapist's automatic simulation of the patient's emotional expression (or "concordant identification" with the patient) would be therapeutic in itself. That is, the therapist's feeling what the patient feels is not in itself likely to be helpful to the patient. What makes it helpful is that it provides an important basis for the therapist's empathic understanding of the patient. What also makes it helpful is that the therapist experiences *something like* what the patient experiences rather than a *replica* of the patient's experience. If, as we believe, the therapeutic interaction is characterized by ongoing, back-and-forth patient and therapist simulations, then the patient's simulation of the therapist's *modified* expression of the patient's experience is likely to serve therapeutic regulatory functions. It is as if the patient "sees" in the therapist a more manageable version of what the patient is experiencing. We believe that this is essentially what is conveyed by the idea that the therapist "metabolizes" the patient's affects (step 3 of Ogden's account of projective identification). However, we note once again that the process we describe is a ubiquitous one that does not necessarily require either the patient's projections or active and specific interpersonal pressure. To interact with another is already to be "induced" to experience something of what that other is experiencing.

We are not suggesting that patients do not engage in projection or exert interpersonal pressure. We are saying simply that the phenomenon of the therapist's experiencing something like what the patient is experiencing can occur in their absence. It also seems to us that when one attributes the therapist's experience to the patient's projections and

interpersonal pressure, one needs some kind of independent clinical evidence that these processes have occurred. The mere fact that the therapist's experiences are similar to the patient's does not itself suffice as such evidence.

Projective identification is most frequently evoked in the literature when the analyst experiences unusual, alien, and uncomfortable feelings that appear not to be readily attributable to the patient's overt behavior and that are often described as if the analyst were possessed by some external force (see, e.g., Bilu 1987). In such cases, the assumption is often made that the analyst's feelings reflect the patient's unconscious projections and interpersonal pressure. If, however, the projections and pressure are not reflected in some way, however subtle, in the patient's behavior, there is little or nothing that mirror neurons, and embodied simulation theory can offer. There is no behavior to simulate or neural structures to share. However, unless the patient's projections generate *some* behavioral cues to which the analyst can respond (consciously or unconsciously), it is difficult to understand how these projections, and the accompanying interpersonal pressure, can possibly influence the analyst's experiences—unless one wants to posit some magical or telepathic processes between patient and analyst. Indeed, telepathy is often enough proposed as an explanation: for example, Ponsi (1997) writes with regard to projective identification that "the intrapsychic event originating in the patient gives rise to a corresponding modification of the analyst's mental attitude" (p. 247), with no apparent recognition that some mechanism must be involved in order to account for this phenomenon. (For an early attempt at explaining countertransference phenomena in terms of "occult processes," see Deutsch 1926.) Under these circumstances, it would be far more plausible and parsimonious to conclude that the analyst's unusual alien feelings, though in some way triggered by the patient, are likely to originate primarily in his or her own history and dynamics and may not be a reliable source for understanding the patient's mind. These feelings can be understood more aptly as countertransference reactions in the classical sense of the term, that is, as impediments to an adequate understanding of the patient.

The Mirroring System, Mirroring, and Attunement

At this point we need to clarify certain distinctions among closely related concepts, including the differences between the mirror neuronal

system and mirroring in the psychoanalytic context, (as used, e.g., in the phrase "empathic mirroring"). As noted, the former refers to shared neural networks in the observer of, say, an emotional expression and in the one experiencing the emotion. This neuronal mirror system (along with the embodied simulation it is hypothesized to involve) does not necessarily imply active or conscious mirroring in the psychoanalytic sense. The latter entails an additional step in which the observer's behavior—say, emotional expression—is in some way congruent with and attuned to the emotional expression of the one being interacted with. (A good example of this kind of mirroring can be found in infant-mother interactions.) We say "in some way congruent with" because empathic understanding of another is reflected not in imitation or duplication of the other's behavior, but rather in congruent and attuned responses, including complementary or modulating responses. In this sense, the term *mirroring* is misleading. An empathic response does not literally mirror the other's behavior. Thus, if a mother observes the baby crying, she does not also cry, a response that would reflect contagion rather than empathic attunement and that would not be especially helpful to the baby. In our view, a person's observation of another's behavior elicits automatic simulation of that behavior, and it is this mechanism that enables empathic understanding, which can eventually lead to complementary or modulating responses.

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Does that not imply imitation or literal mirroring? We think not. For one thing, simulation does not necessarily imply overt imitative behavior. There is evidence that automatic simulation is often accompanied by inhibitory mechanisms that allow one to simply observe another's behavior rather than carry it out oneself. For another thing, person B's simulation of person A's behavior cannot constitute an exact duplication, insofar as there are two different people or two different brains involved. A's simulation of B's behavior is filtered through the former's past experiences, capacities, and mental attitudes. In the context of empathic understanding, what is important is that A's simulation needs to be sufficiently accurate to generate responses congruent with, or attuned to, B's behavior and experiential states. For example, the mother's simulation of her infant's behavior and the responses it generates need to be attuned to but different enough from the infant's experience and behavior to be helpful to the infant in developing a sense of his or her own mind and in regulating his or her affective states (see also the important concept of "marking" [Fonagy et al. 2002]; see

also Vygotsky's concept of "zone of proximal development" [1934]). These processes would not be served by literal mirroring of the infant behavior. We are reminded here of Beebe, Lachmann, and Jaffe's finding (1997) that in contrast to high or low attunements, the mother's moderate level of attunement to her infant during the first few months of life is associated with secure infant attachment at one year of age.

A mother who responds to an infant who is in distress and is crying with, say, "Oh, poor baby" and an appropriate facial expression and tone of voice is not imitating the baby's distress, but is responding in a manner *congruent* with or attuned to it. Such a response does not simply mirror the baby's state; it modulates and regulates that state in a way that direct imitation would obviously not. Literal mirroring would lead to mere "repetition," a lack of growth or progress both in the child and in the patient (as well as in adult life, for that matter).

For these reasons we think that the term *mirroring,* as used in the psychoanalytic literature, is misleading insofar as it implies that the observer's (e.g., the caregiver's) response is a replica or imitation of the observed's (e.g., the infant's) behavior. We suggest that the term be replaced with such locutions as *attunement* or *congruent response.* Or at least it should be emphasized that mirroring should not be (and cannot possibly be in nature) a perfect reproduction of the other's mental states.[4]

The mother's attuned or congruent response permits the infant to find him- or herself in the eyes of the mother. According to Fonagy and his colleagues (e.g., Fonagy and Target 1996a,b, 2000), the mother's ability to match the infant's mental states contributes to the infant's capacity to develop a concept of its own mind and the minds of others (a forerunner of Fonagy's formulation can be found in Bion's idea [1962] that maternal reverie can allow containment of the child's thought elements, which will be transformed and later used by the child to build his or her thinking apparatus). What makes active attunement possible and what constitutes the biological basis for such attunement, we propose, is the existence of the mirror neuronal system and automatic embodied simulation. However, the mere existence of such a mirror system, while necessary for attunement, is not sufficient to guarantee it.

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[4]See, in this regard, the interesting observations made by Lichtenstein (1964) on the role of mirroring in promoting growth and differentiation: "The mirror introduces a third element. . . . What, or who, is symbolically represented by the mirror? Finally, he who looks into a mirror does not see only himself. A mirror reflects a great more many things than the person who looks into the mirror" (p. 212).

For although the mirror system and embodied simulation may be hard-wired universal processes, we know that there is a wide range of individual differences in people's capacity to understand and empathize with others. This is true not only in regard to infant-mother interactions, but in general interpersonal relations, including patient-therapist interactions. We turn now to this issue of individual differences in empathic understanding.

Individual Differences in Empathic Understanding

We know that there are many factors—including cultural, age, and gender differences between individuals—that influence the capacity to understand and empathize with others. We also know, or think we know, that quite frequently people react to others not so much in terms of their actual characteristics (that is, what they intend, desire, feel, and so on), but more as if these others were stand-ins for early objects. Indeed, is not this presumably ubiquitous tendency the essence of the traditional concept of transference? And, if Fairbairn (1952) is correct, the ability to react to and understand another, not as a stand-in for an internalized object but as who that other actually is, is not a taken-for-granted given; rather, it is an achievement that constitutes a central criterion of mental health.

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Of course, most normal individuals generally have a good enough automatic understanding of the actions, intentions, and emotional experiences of other members of the species. So, in a general sense, the processes underlying such understanding work well enough to permit meaningful interpersonal and social interaction. Still, we must address the evident range of individual differences in the capacity to understand and empathize with others. The question, then, is: If we all possess a mirror neuronal system, and if we all automatically and reflexively carry out embodied simulation, why is there such a wide range of individual differences in our capacity to understand the other, and why are there obvious failures and defects in this capacity? What accounts for these differences and failures? At what level of functioning do these differences and failures exist?

Autism and the Mirror Neuron System

To take an extreme case, it is generally agreed that autistic individuals are relatively unable to understand and grasp others' intentions and the meaning of their actions and emotional expressions (Dawson et al.

2002). Recent evidence indicates that when these individuals observe another's actions, they do not show an activation of the mirror neuron mechanism that one finds in nonautistic individuals, a finding that suggests that the formers' intersubjective empathic failures are attributable, in part at least, to defects at the basic level of embodied simulation and the underpinning mirror neuron systems (Gallese 2006). Following is some evidence supporting this hypothesis.

Recent studies employing different techniques (EEG and TMS) show that individuals with Autistic Spectrum Disorder (ASD) might be suffering an action simulation deficit induced by a dysfunction of their mirror system for action. Previous experiments carried out on healthy individuals showed that during action observation and action execution there is a suppression of the *mu* frequency of the EEG over the primary motor cortex. Other experiments employing TMS demonstrated that during action observation healthy individuals normally show a facilitative effect on the same muscles they would employ in carrying out the action they are observing. In one study, Theoret et al. (2005) showed that in contrast to nonautistic controls, ASD individuals did not show TMS-induced hand muscle facilitation during hand action observation. In another study, Oberman et al. (2005) measured EEG *mu* suppression, which is thought to reflect mirror neuron activity, in ten individuals with high-functioning ASD and ten age- and gender-matched controls. They found that while the control subjects showed significant *mu* suppression during both self-performed and observed hand movement, the ASD subjects showed significant *mu* suppression during self-performed hand movement, but not to observed hand movement. These results lend support to the hypothesis of a dysfunctional mirror neuron system in ASD individuals, a dysfunction that may play a role on the difficulty they have in understanding others' behaviors.

Another instantiation of simulation deficits in the autistic syndrome is exemplified by difficulties with imitation. Autistic children have problems in both symbolic and nonsymbolic imitative behaviors, in imitating the use of objects, in imitating facial gestures, and in vocal imitation (see Rogers 1999; Williams, Whiten, and Singh 2004; Williams et al. 2006). These deficits characterize both high- and low-functioning forms of autism. Further, imitation deficits are apparent in comparison not only with the performances of healthy subjects, but also with those of mentally retarded nonautistic subjects. According to our hypothesis, imitation deficits in autism are determined by the

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incapacity to establish a motor equivalence between demonstrator and imitator, most likely because of a malfunctioning mirror neuron system, or a disrupted emotional-affective regulation of the system. Imitation deficits thus can be characterized as further examples of defective embodied simulation (Gallese 2006).

Let us now briefly turn to emotional-affective deficits. Several studies have reported the severe problems autistic children experience in the facial expression of emotions and their understanding in others (Snow, Hertzig, and Shapiro 1988; Yirmiya et al. 1989; Hobson 1989, 1993a,b; Hobson, Ouston, and Lee 1988, 1989). In a recent fMRI study, Dapretto et al. (2006) specifically investigated the neural correlates of the capacity for imitating the facial expressions of basic emotions in high-functioning ASD individuals. The results of this study showed that during observation and imitation children did not show activation of the mirror neuron system in the pars opercularis of the inferior frontal gyrus, part of the frontal mirror neuron system. It should be emphasized that activity in this area was inversely related with symptom severity in the social domain. The authors of this study concluded that a dysfunctional mirror neuron system may underlie the social deficits observed in autism. McIntosh et al. (2006) recently showed that individuals with ASD, in contrast to healthy controls, do not show automatic mimicry of the facial expression of basic emotions, as revealed by EMG readings. Further, Hobson and Lee (1999) reported that autistic children score much worse than healthy controls in reproducing the affective qualities of observed actions. All these deficits can be explained as instantiations of intentional attunement deficits produced by a malfunctioning of the mirror neuron system. This hypothesis is further corroborated by the recent finding (Hadjikhani et al. 2005) that the brains of ASD individuals show abnormal thinning of the gray matter in cortical areas known as being part of the mirror neuron system, including the ventral premotor, posterior parietal, and superior temporal sulcus cortices. Interestingly, cortical thinning of the mirror neuron system correlated with ASD symptom severity.

Our proposal to interpret the autistic syndrome as an intentional attunement deficit is divergent, in certain respects, from many mainstream ideas concerning the origin of this developmental disorder. One of the most credited theories on autism—in spite of its different, not always congruent articulations—posits that it is caused by a deficit of a specific mind module, the Theory of Mind module, selected in the

course of evolution to build theories about the minds of others (Baron-Cohen, Leslie, and Frith 1985; Baron-Cohen 1988, 1995). One of the many problems with this theory is that it can hardly be reconciled with what we learn from reports on some high-functioning autistic or Asperger individuals. These reports claim (see Grandin 1995) that these individuals in order to understand how they supposedly should feel in given social contexts, and to understand what others supposedly feel and think in those same contexts, must rely on detached theorizing. The world of others can be "pictorially" described and theoretically explained, but a direct experiential grasp of its meaningfulness is totally precluded. What these reports seem to suggest, as argued elsewhere (Gallese 2001, 2006), is that the *basic* deficit is not in the capacity to theorize about the minds of others. Instead, in these individuals theorizing is the only compensating strategy available in the absence of more basic cognitive and affective skills that would enable a direct experiential take on the world of others.

Impairments in Understanding in Nonautistic Individuals

Given the nature and severity of the failures in understanding others' actions, intentions, and emotional expressions that are observed in autism, it is perhaps not surprising to find evidence of defects at the very basic level of neuronal systems. However, it seems unlikely that individual differences, including both garden-variety and more subtle impairments in the understanding of others, are due to gross malfunctioning at this fundamental level. It is possible that more subtle variations in understanding others are attributable to processes that occur primarily at a "higher" level of functioning. If, as we assume, normal individuals have intact mirror neuron systems and embodied simulation, variations in understanding others would be attributable to processes beyond this fundamental level. These processes, we hypothesize, are likely to be the ones that are the focus of psychoanalytic attention. For example, because of the nature of their defenses, some individuals—both patients and analysts—may have greater difficulty having preconscious access to and reflecting on inner cues presumably universally generated by the basic mirror neuron and embodied simulation systems. In principle, this is a researchable hypothesis. It would be useful as well to examine the research literature on individual differences in empathic ability.

Another possibility is that these variations in empathic ability are due to more or less subtle variations in the mirror neuron system, which

cannot be adequately developed because of developmental deficits and traumas (e.g., lack of parental empathy and attunement). In other words, it could be a quantitative issue. Some studies try to investigate the possibility of repairing these deficits with specific psychotherapeutic techniques in which the therapist's empathy and a focus on the patient's reflective function plays a major role (see, e.g., Bateman and Fonagy's mentalization-based treatment for adult borderline patients [2004], which seems to yield promising results).

Another factor that may contribute to subtle impairments in understanding others is our tendency to assimilate new experiences to preexisting schemas. This tendency is at the core of transference reactions, as well as countertransference in its classical sense. That is, because of unresolved conflicts or rigid schemas, one may have blind spots in understanding another or show distortions in understanding. It is unlikely that these impairments and distortions are attributable to processes at the level of mirror neurons and embodied simulation. However, there is the interesting question of whether when A experiences B's smile or tone of voice, for example, as friendliness, processes become activated at the level of mirror neurons different from those seen when A perceives B's behavior as condescension. Is it possible that "higher-level" factors such as schemas, defenses, conflicts, and mental attitudes can influence the nature of mirror neuron activation and embodied simulation in a top-down fashion? This, too, is in principle a researchable question. In fact, as noted earlier, there is evidence that mental attitudes can influence the operation of the mirror neuron system (Singer and Frith 2005).

Empathy and Unconscious Mental States

In considering the possible implications of the work on mirror neurons and embodied simulation for psychoanalysis, one must take into account the fact that the former deals with explicitly observable behavior, such as actions and emotional expressions, whereas analysts presumably deal with the unconscious mental states of patients, as inferred from their verbalizations. This is an issue that is relevant not only in regard to the relationship between mirror neurons and psychoanalysis, but to the broader question of the role of empathy in psychoanalytic understanding.

This raises the question of what it means to be empathic with, say, the unconscious wishes and desires of another. What does it mean to

take the perspective of another in regard to the patient's unconscious mental states, particularly their ego-alien aspects? Schlesinger (1981) argues that psychoanalytic interpretations pertaining to unconscious, ego-alien aspects of the patient are by definition not empathic, insofar as they do not resonate with, and are indeed are inimical to, the patient's conscious experience. Can one "rescue" the role of empathy in relation to unconscious mental states by thinking of it as putting oneself in the shoes of another who is harboring certain wishes and desires, but also warding them off? (see Eagle and Wolitzky 1997). This is but one of the issues and questions that arise when one elevates empathy or "vicarious introspection" as the primary tool for understanding the patient.

It is interesting to observe that the near exclusive focus on empathy as a primary tool of understanding in psychoanalysis has been accompanied by a markedly decreased emphasis on unconscious mental states and, in general, by what seems to be a "phenomenological turn" in contemporary psychoanalysis (Migone 2004). In fact, empathy in a way belongs to the phenomenological tradition, while in psychoanalytic circles it has become the center of considerable attention only in recent decades, mostly after the introduction of Kohut's self psychology. Thus, in Kohut's entire 1984 book there are but six instances of the word *unconscious*. Three of these are one-word references to Freud's use of the term, while the other three occur in the context of to Kohut's critical assessment of Freud's views—for example, Freud's view of the unconscious as an abscess that needs to be drained, his emphasis on knowing, and his (presumed) experience of not knowing as a narcissistic injury. In other words, there is not a single instance in the book in which the concept of unconscious processes is relevant to self psychology—a remarkable fact for a discipline that has traditionally identified unconscious processes as its central focus. This is not surprising, however, when one considers Kohut's emphasis, not only on empathy, but on "experience-near" concepts.[5]

In an important sense, the concept of unconscious mental contents, particularly of warded-off, ego-alien unconscious mental contents, is

[5]It is interesting to observe that Kohut (1984) distinguishes between explanation and understanding, a distinction that has a long philosophical history. For example, central to the *Verstende* movement was the claim that in contrast to the physical sciences *(Naturwissenschaften),* which rely on theoretical explanation, the human sciences *(Geisteswissenschaften)* employ a *verstehen* or understanding. It is clear that Kohut's distinction belongs to this European tradition.

an experience-distant concept. Because they are not easily and directly accessible to conscious experience and because one does not, in any simple way, have first-person "privileged access" to them, unconscious mental contents and processes are explicitly inferred by the observer (and sometimes even by the agent him- or herself). Explicit inferences are the kind of things that are much more closely linked to theory-driven explanations than to understanding arrived at through empathy.[6]

This suggests that for most analysts who do not define psycho-analysis solely in terms of reliance on "vicarious introspection," both empathic understanding and theory-based inferences are employed, often seamlessly, in obtaining a picture of the workings of the patient's mind.

Mirror Neurons, Embodied Simulation, and Aspects of Therapeutic Action

Up to this point we have been discussing the implications of the mirror neuron system and related findings for how one gains knowledge and understanding of the patient's mind. We want to turn now to the implication of these findings for therapeutic action. Recall that for Kohut (1984) empathic resonance is not only a means of gaining knowledge of the patient's mind, but also a primary vehicle of therapeutic cure. That is, according to Kohut, the patient's repeated experience of empathic understanding by the analyst serves to "repair" self-defects. Why should this be the case, and how would such "repair" come about?

Kohut does not identify a mechanism beyond vague references to terms like accretions in psychic structure. We want to speculatively suggest a mechanism in which the therapist's accurately attuned response to the patient is automatically simulated by the patient, enhances the patient's sense of "we-ness" (a sense of connectedness to the other), and thereby contributes to a feeling of self-integrity. The patient's embodied simulation of the therapist's attuned response has the potential to clarify and articulate the patient's own feeling state and therefore can itself contribute to self-integrity (this could be the curative factor of Bateman and Fonagy's mentalization-based treatment. Note that what we are describing here is a circular, back-and-forth interaction of embodied simulations between patient and therapist.

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[6]In a symposium on the place of empathy in psychoanalysis, Schwaber (1981), an analyst strongly associated with self psychology, distinguishes between "inferential explanation" and empathic understanding.

The therapist's attuned response to the patient, which is itself underpinned by the former's embodied simulation of the latter's emotional expressions, triggers in the patient an embodied simulation of the therapist's response. This process helps the patient "see" his or her emotional states in the therapist's response, as well as experience the modulation and containment of such states. More generally, as Fonagy et al. (2002) have suggested, the patient experiences him- or herself safely represented in the therapist's mind, which helps the patient not only toward self-discovery but, perhaps more important, toward the discovery of self in the mind of the other.

One can analogize here between the mother's mirroring of the infant and the therapist's attuned response to the patient. According to Fonagy et al. (2002), the infant adjusts its emotions by monitoring the reactions of the mirroring caregiver and assigning meaning to his or her sensations and bodily experiences through the experience of the caregiver's affective responsiveness, where the caregiver functions as "social biofeedback" (Gergely and Watson 1996). Similarly, as argued above, the patient learns to more accurately identify his or her affective states through "observing" them as they are reflected in the therapist's attuned response (of course, with adults, the therapist has the option of making explicit interpretations regarding affective and other mental states of the patient). We are suggesting that both for the infant and the for adult this process is enhanced through the infant's or adult's embodied simulation of, respectively, the caregiver's or the therapist's attuned response.

We describe below in outline form what such a process might look like in the infant-caregiver context.

1. Say that the child (A) experiences a particular feeling state.

2. Caregiver (B) reacts to A.

3. A observes and reacts to B's reaction to him or her.

4. A's observation of B's reaction triggers automatic, prereflexive, simulation of B's behavior in A.

5. If B's reaction to A (in step 2) is isomorphic with or attuned to A's feeling state (in step 1), then the simulation processes automatically triggered in A (step 4), when he or she observes B's reaction to him or her, will be *congruent* with his or her initial feeling state (in step 1). This not only will contribute to A's sense of connectedness to B, but will also positively influence the development of A's sense of self through contributing to the continuity and reinforcement of A's feeling states.

6. If B's reaction to A (in step 2) is misattuned to A's initial feeling (step 1), then the simulation processes automatically triggered in A (step 4) when he or she observes B's reaction to him or her will be *incongruent* with his or her initial feeling state (in step 1). This means that there will be a *disjunction* between A's initial feeling state (in step 1) and his or her internalization (that is, the simulation processes triggered in A) of B's reaction to him or her. Such disjunction, one could speculate, threatens self-integrity by contributing to the development of what Winnicott (1965) calls a "false self" and what Fonagy et al. (2002) refer to as an "alien self" (the latter, quite close in meaning to Fairbairn's concept [1952] of "internalized object"). These concepts have in common the central idea that the individual has "imported" into the structure of the self (mirroring) reactions of the other that are incongruent with one's constitutionally and organically based "true" feeling states. It is natural for the infant to simulate the caregiver's reactions. However, if what is simulated is incongruent with the infant's feeling state, then he or she is internalizing or taking in, as part of the self, representations that are incongruent with his or her own organically or constitutionally based self. Surely, this is what the terms false self, alien self, and internalized object basically mean.

7. It should be noted, as we have seen, that the caregiver's (B's) literal mirroring, that is imitation of the infant's (A's) behavior, is not likely to facilitate growth and the development of the latter's capacity to regulate affect and to assign meaning to his or her sensations and experiences through monitoring the reactions of the caregiver with social biofeedback. To repeat the example cited earlier, mother crying in response to baby's crying leads only to "repetition," and is not likely to help the baby regulate distress or learn that distress is a state that can be relieved through certain interactions with another.

One can speculate that interactional processes similar to the ones described above go on in the therapeutic situation; that is, when the patient experiences and expresses a particular feeling state, ideally the therapist reacts not with literal mirroring, but with congruent or attuned responses (i.e., with empathic understanding) that allow the patient to both "find" his or her own experiences in the therapist's response and, at the same time, facilitate the patient's capacity to reflect on and transform that experience. Using a neurophysiological explanation of this phenomenon, one can further speculate that therapeutic change is made possible only when the "quantitative" difference between

the two feeling states (i.e., the patient's state and the one that has been internalized from the therapist) is small enough that it does not destabilize the patient's identity. In a way, this reminds us of the "small steps" technique employed in behavior therapy, where the patient gradually changes through a seamless learning process.

We want to emphasize that under these circumstances, when the patient internalizes the therapist's responses, what is internalized is not simply a representational replica of the patient's own behavior, but already a transformation of that behavior. This, we assume, is one important aspect of the growth process in successful therapy. We are reminded here of the caricature of so-called nondirective Rogerian therapy, in which repeatedly the therapist concretely and literally reflects the patient's experience of suicidal feeling states, simply or changing a word or two. The caricature ends with the patient jumping out the window and the therapist's final mirroring reflection—the word *plop*. No wonder Rogers abhorred the term *reflection* as a description of his approach; he was well aware that in empathy there is more than mere reflection. In any case, when the therapist's reactions to the patient are congruent with the latter's feeling state, the patient feels empathically understood and there is both an enhanced sense of connectedness to the other and a validation and expansion of the self.

Mirror System, Embodied Simulation, and Countertransference

A central characteristic of contemporary psychoanalysis is the assumption that the analyst's countertransference reactions, now "totalistically" defined as including the entire range of the analyst's cognitive and affective reactions to the patient (Kernberg 1965), may serve as an important guide to what is going on in the patient's mind (see Gabbard 1995). It is interesting to consider this assumption in light of the findings presented here and the hypothesis of embodied simulation. If the analyst's observation of the patient's actions and emotional expression (which, we would assume, also includes the affective tone of verbalizations) activates the same neural pattern in him or her that is activated in the patient, thus triggering an automatic simulation process in the analyst, then it is plausible to hypothesize that the analyst's sensitivity to and awareness of his or her own spontaneous thoughts and feelings when interacting with the patient may constitute a potentially important source of information regarding what is going on in the patient's mind. In other words, the embodied simulation underpinned by activation of the

mirror neuron system lends support to and provides a possible neural substrate for current psychoanalytic assuptions regarding the use of countertransference in the analytic situation.

Similar reasoning holds also for the conceptualization of the patient's transference reactions. To the extent that the analyst's behavior approached a "blank screen" model, there were few behavioral and affective cues that he or she emitted (or that he or she *believed* were emitted). However, as the analytic situation has become more interactional, it is reasonable to consider that the patient's observation of the analyst's behavior and emotional expressions activates in the patient the same neural patterns activated in the analyst and also triggers in the patient an automatic simulation process. In other words, both patient and analyst bodily internalize aspects of each other's behavior and emotional expressions. Another way to put this is to say that as far as general neural processes are concerned, there are as good grounds for positing the patient's empathic resonance with the analyst as for the analyst's empathic resonance with the patient. To the extent that the analyst "hides" behind the couch, the initial condition of mutual empathic resonance is tilted in favor of the analyst. That is, the patient has fewer cues to observe and simulate than the analyst.

An early and abiding rationale for use of the couch is the freer free association it presumably makes possible. That is, freed from facing another, the patient was assumed to be less constrained by social considerations and so to produce associations containing more unconscious derivatives. In addition, the analyst's "hidden" position, along with a neutral stance, presumably renders him or her more of a "blank screen" on which the patient can project early wishes, fantasies, etc. A question that seems worth asking in the present context is what is lost and gained by use of the couch. We have seen what presumably is gained. What appears to be lost are reduced opportunities for the patient to examine and reflect on transference reactions in the light of cues emitted by the analyst (see Gill 1984; Migone 2000) and to understand and internalize various aspects of the analyst's reactions and the effects these reactions have on him or her. If one considers such interactions an important aspect of the therapeutic process, then indeed a good deal may be lost by use of the couch (for further discussion of this issue, see Olds 2006).

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Theory-Theory and Simulation Theory in the Psychoanalytic Context

In coming to the end of this paper, we want to draw some parallels between, on the one hand, what we will call the "standard model" of classical psychoanalytic theory and a theory-theory account of our mind-reading ability and, on the other hand, more recent models of psychoanalysis and a simulation theory of that ability. An examination of the parallels should help elucidate the direction psychoanalysis has taken in recent years. Although, as noted, Freud wrote about communication between the unconscious of the patient and of the analyst and although he referred to the role of the analyst's empathy *(Einfühlung)* in understanding the patient, his comments on these matters were presented mainly as informal observations and were not systematically incorporated into the classical theory of psychoanalytic treatment. The emphasis in this perspective is on interpretations designed to identify the unconscious derivatives and meanings of the patient's verbal productions (free associations, dream reports). Although such interpretations are undoubtedly influenced by the analyst's personal intuitions—indeed, Freud recommended an analytic attitude of "evenly suspended attention" that would presumably facilitate such intuitions—according to the classical perspective they are guided mainly by inferences based on knowledge of a psychoanalytic theory of mind (of course, they are also influenced by the analyst's clinical experience and his or her training analysis. In order to carry out this task of "interpret[ing] and detect[ing] hidden elements in the patient's mind" the analyst needed to "remain emotionally immune to the temptations of counter-transference" (Cohen and Schermer 2004, p. 581) and to strive for "the objectivity of a neutral observer and [in Freud's words] the detachment of a surgeon" (p. 584). In this sense, the standard model is more closely aligned with a straightforwardly cognitive theory-theory account of our mind-reading ability. That is, according to this view, our understanding of another's mind is based on explicit and implicit theories of how minds function and that account for people's behavior in terms of inferences regarding their beliefs, desires, and intentions.

The Current Psychoanalytic Model and Simulation Theory

Contemporary psychoanalysis has increasingly moved from a "standard model" account, in which the neutral and objective analyst comes to understand the patient's mind on the basis of a general theory of mind, to a stance in which, in addition to relying on theory, the analyst

comes to understand the patient's mind through reflection on a range of personal, affectively tinged experiences, including partial identifica-tions (i.e., putting him- or herself in the shoes of the patient), as well as "complementary" countertransference reactions (Racker 1960) that may be elicited by the patient. In short, contemporary psychoanalysis has increasingly moved from a theory-theory to a simulation theory account of how the analyst comes to understand the patient's mind.

Of course, this is not an all-or-none or either-or matter, but rather one of relative emphasis. Most contemporary analysts combine theo-retical inferences with sensitivity to their intuitions and counter-transference reactions in their effort to understand the patient. However, the increasing emphasis on the latter, along with the interactional conception of the analytic situation, represents perhaps the clearest expression of an implicit simulation theory operating in contemporary psychoanalysis. That is, there is an increasing implicit recognition in contemporary psychoanalysis that even the seemingly passive act of observing another entails automatic interactional processes. Such recognition is congruent with a theory of embodied simulation that hypothesizes that when A is observing, say, B's emotional expression, there is an automatic simulation of the neural processes that subserve B's behavior (and, of course, insofar as A and B are interacting, the reverse is also true, that is, that B simulates A's neural processes). It is the intersubjective process of embodied simulation, we propose, that permits the kind of direct, noninferential understanding that consti-tutes a basis for the therapeutic use of the analyst's countertransference reactions. In short, we are witnessing a central aspect of the shift in contemporary psychoanalysis from a primarily theory-theory account to one that places increased emphasis on a simulation theory account in understanding another's mind.

But we want to emphasize, in this respect, that psychoanalysis, as any form of therapy or scientific endeavor, must of course rely ulti-mately on a conscious effort of building a theoretical account of the therapeutic interaction. Otherwise the latter could not be reproduced or taught. It would exist, but we could not talk about it, and the analyst would have only his or her idiosyncratic intuition to rely on in conducting treatment. This is a legitimate option, but it would not make psychoanalysis a science. Further, as we have noted, the current psychoanalytic model may entail the danger of deemphasizing the role of insight (a term that, incidentally, sees a progressive decline in its use),

reducing psychoanalysis to a mere corrective experience (Alexander and French 1946) without conscious reflection and understanding.

Given the evidence on the relation between language processing and motor simulation and some recent brain imaging results on explicit mentalization,[7] it is likely that conscious reflection and understanding rely on both theorizing and conscious simulative efforts, according to the standard mechanism envisioned by simulation theory (Goldman 2006).

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[7]A recent brain-imaging study has shown that when participants ascribed mental contents to themselves as well as when they judged the potential mental states of others thought to be similar to them, in both conditions the very same region within the ventral medial prefrontal cortex was activated (Mitchell, Macrae, and Banaji 2006). On the basis of this evidence these authors concluded that "perceivers make selective use of simulation in the original sense, plumbing their own possible—but not necessarily concurrently experienced—thoughts and feelings for clues to those of others" (p. 659).

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