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Editorial
Social neuroscience approaches to interpersonal sensitivity

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Interpersonal sensitivity refers to our ability to perceive and respond with care to the internal states (e.g., cognitive, affective, motivational) of another, understand the antecedents of those states, and predict the subsequent events that will result. This special issue brings together new research findings from empirical studies, including work with adults and children, genetics, functional neuroimaging, individual differences, and behavioral measures, which examine how we process and respond to information about our fellow individuals. By combining biological and psychological approaches, social neuroscience sheds new light on the complex and multi-faceted phenomenon of interpersonal sensitivity, including empathy. One should, however, be aware of the challenges and limits of such an approach.

Human beings are intrinsically social. Our survival critically depends on social interaction with others. Most of our actions are directed toward or are responses to others (Batson, 1990). No single factor can account for human social cognitive evolution (e.g., diet or climate), but the single most important factor is the increasing complexity of hominid social groups (Bjorklund & Bering, 2003).

For a long time, social sciences and neuroscience have developed independently. Social psychology is interested in the scientific study of how people's thoughts, feelings and behaviors are influenced by the actual, imagined or implied presence of other individuals. Neuroscience studies the nervous system and its constitutive unit, the neuron, and conceptualizes individuals as somewhat isolated units of analysis. Social neuroscience challenges these views by exploring the biological underpinnings of the processes traditionally examined by, but not limited to, social psychology (Decety & Keenan, 2006). It is an exciting endeavor. On the one hand, theories in social psychology can provide important guidelines for investigating the information-processing mechanisms and their neural instantiation. On the other hand, neuroscience may help disambiguate competing social theories, for instance the distinction between personal distress and empathic concern.

In this special issue, titled "Interpersonal Sensitivity: Entering Others' Worlds," we bring together new research findings from empirical studies that document how we process information about our fellow individuals. This title was chosen as a broad umbrella to accommodate a large array of approaches, including work with adults and children, genetics, neuroimaging, etc. By interpersonal sensitivity, we mean the ability to perceive and respond with care to the internal

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states (e.g., cognitive, affective, motivational) of another, understand the antecedents of those states, and predict the subsequent events that will result. *Social Neuroscience* seeks to facilitate collaboration across a broad range of disciplines, including but not limited to neuroscience, philosophy, psychiatry, clinical, developmental, and social psychology. It also encourages a broad range of empirical measures, including but not limited to functional neuroimaging, psychophysiology, behavioral observation, comparison of patient and non-patient populations, and comparison of genetic alleles. In this special issue, we sought breadth in a third direction as well. We sought to include research focused on several different but related aspects of the complex and multi-faceted phenomenon that we have labeled interpersonal sensitivity.

ASPECTS OF INTERPERSONAL KNOWLEDGE AND INTERPERSONAL SENSITIVITY

A sensitive response to others requires at least some knowledge. Contributions to this special issue highlight the following different aspects of interpersonal knowledge and interpersonal sensitivity.

Interpersonal knowledge

Knowledge of the internal states of others includes at least three distinct but related phenomena. First is knowing *that* others are thinking and feeling (i.e., that they are cognizant and sentient). This is Theory of Mind (ToM) at the most basic level. Second is knowing *what* others are thinking and feeling (e.g., empathic accuracy). Third is *how* we know what others are thinking and feeling. This is more substantive ToM. Many possible ways of knowing are considered by contributors to this special issue: mimicry, mirroring, perception–action overlap, shared neural representations, simulation, theory-theory, narrative accounts, identification, similar prior experience, and perspective taking.

Interpersonal sensitivity

Interpersonal sensitivity also includes at least three distinct but related forms. One form is *feeling as* another person feels (i.e., ‘‘matching through catching’’ another’s emotional state). This phenomenon has been variously called emotional contagion, resonance, or (parallel) empathy. It should be distinguished from both (a) a parallel response to the same environmental situation (e.g., use of another’s emotional display as a cue to aspects of the situation that then evoke a parallel emotional response) and (b) association or conditioning (e.g., response to another’s display as a conditioned stimulus due to prior pairing of one’s own and others’ response, evoking a parallel emotional response).

A second form of interpersonal sensitivity is *feeling for* another person (i.e., an other-oriented emotional response evoked by and congruent with the perceived welfare of another). This phenomenon has been called sympathy, compassion (reactive) empathy, or empathic concern. It should be distinguished from more self-oriented emotional reactions to another’s plight, including personal distress, disgust, anxiety, or fear.

A third form if interpersonal sensitivity is *caring for* another person (i.e., love or attachment). We may care for or value another’s welfare, making us vigilant or sensitive to the way he or she is affected by events. When a cared-for other is perceived to be in need, we are likely to feel for this person. Remove the need, and we no longer feel for—but we still care for—this person.

The contributions to this special issue address in a variety of ways each of these forms of interpersonal knowledge and interpersonal sensitivity. Interpersonal knowledge and sensitivity involve a complex mix of automatic and unconscious processing that can be described as bottom-up, and self-regulatory functions that tap into meta-cognitive resources and are best described as top-down. Several contributions focus on bottom-up processing whereas others investigate top-down processing. Both approaches are necessary to understand the whole complexity of social interaction. But exactly how these approaches relate is not yet clear. In this regard, the contributions raise a number of key theoretical issues.

CONTENT OF THE SPECIAL ISSUE

In the past decade an impressive body of work in various fields of research, including social psychology, developmental science, cognitive psychology and neuroscience has provided strong evidence for a direct link between perception and action (Sommerville & Decety, 2006). When we observe the actions of others, neural circuits related to performance of their actions are activated in us (mirror-neuron systems). Interestingly, this motor resonance seems specific to actions made by humans as compared to robots as shown by work in developmental psychology and neuroscience. Based on their previous research, which had shown that observing an action made by a human, but not by a robot, interferes with the execution of a different action, Kilner and Blakemore investigated what aspect of human movement, not present in robotic movement, causes this interference effect. In their study, participants made arm movements while observing a video of either a human making an arm movement or a ball moving across the screen. The executed and observed arm movements were either congruent (same direction) or incongruent (tangential direction) with each other. The results showed that observed movements are processed differently according to whether they are made by a human or a ball. For the ball videos, both minimum jerk and constant velocity incongruent movements significantly interfered with executed arm movements. In contrast, for the human videos, the velocity profile of the movement was the critical factor: only incongruent, minimum jerk human movements significantly interfered with executed arm movements.

Also using an interference technique, the study conducted by Oberman, Winkielman, and Ramachandran investigated the role of spontaneous facial mimicry in the recognition of facial emotions. Their results show that impairing one's ability to use facial muscles leads to a selective deficit in the recognition of emotion that involve those muscles.

To investigate the neural mechanisms underpinning facial emotional processing, Van der Gaag and his colleagues scanned participants during the observation, the discrimination and the imitation of dynamic facial expressions. Results demonstrate that even passive viewing of facial expressions activates a wide network of brain regions that are involved in the execution of similar expressions (aka mirror-neurons system), including the inferior frontal gyrus (IFG), the insula and the posterior parietal cortex. While the viewing of facial expressions recruited similar brain regions in all three experiments, adding an active task (discrimination and imitation) augmented the magnitude of these activations. However, no evidence was found for selectivity in hemodynamic response to specific emotion. The authors argue that understanding facial expressions of emotion involves a simulation process within motor, limbic and somatosensory systems.

This automatic mimicry mechanism may be modulated by social variables, such as whether the target person is a member of an in-group versus an out-group, as reported in a study conducted by Mondillon and colleagues. Their research investigated the automatic imitation of facial expressions of anger by in-group and out-group members, using a temporal estimation task. Individuals typically overestimate duration that is represented by emotional faces, and this bias appears to be due to increases in arousal. Overestimation is not observed, however, when imitation of the facial expressions is inhibited, suggesting that embodied simulation mediates the changes in arousal. This method thus provides an implicit measure of imitation and was used to test the hypothesis that individuals automatically imitate in-group, but not out-group members' facial expressions of emotion. Chinese and French-Caucasian female participants (all living in France), run in separate studies, were trained to categorize short (400 ms) and long (1600 ms) standard durations in a temporal bisection task. They then categorized standard and intermediate durations represented by angry and neutral faces. Half of the face stimuli were Chinese, and half Caucasian. Results revealed a bias in the temporal perception of emotion such that Caucasian perceivers imitated Caucasian facial expressions and not Chinese ones. Results suggested that Chinese individuals imitated faces of both in- and out-group members. The results of the Chinese participants are interpreted in terms of motivations to understand emotional expressions of members of a host culture.

Facial expressions of social emotions can also be modulated by personal dispositions. Burklund, Eisenberger, and Lieberman examined neural responses to a facial expression that primarily signifies a threat to social connection, namely a "disapproving" facial expression. They hypothesized that neural responses to disapproving facial expressions would be moderated by individual differences in rejection sensitivity. Study participants were scanned while they viewed brief video clips of facial expressions depicting disapproval, anger, and disgust. As expected, all three expressions yielded bilateral amygdala activation relative to a resting baseline. But even more interestingly, individuals who scored higher on a measure of rejection sensitivity exhibited greater dorsal anterior cingulate cortex activity in response to disapproving facial expressions, but not in response to anger or disgust facial expressions. Results suggest that, at the neural level, individuals high in rejection sensitivity may be more sensitive to facial expressions signaling potential rejection, but not to threatening facial expressions in general. Their results also suggest that disapproving facial expressions convey a distinct type of threat and should be considered in future studies of socially threatening facial expressions.

Human beings not only resonate with others as demonstrated in the previous studies, they also have the cognitive ability to intentionally adopt or imagine the psychological view point of others. This process, called perspective taking, is thought to play an important role in empathic concern and, possibly, moral reasoning. Preston and her collaborators examine perspective taking in an experiment that combined psychophysiological (i.e., heart rate, respiration rate, and skin conductance) and functional cerebral blood flow measurements with positron emission tomography. Study participants were requested to imagine personal experiences of fear or anger and similar emotional experiences from the point of view of another person. Their results suggest that substrates of cognitive empathy overlap with those of personal feeling states to the extent that one can relate to the state and situation of the other.

Most neuroimaging studies that have explored the overlap in brain response between the observation of behavior performed by others and the generation of the same behavior in self have relied on simple subtraction methods and generally highlight the commonalities between self and other processing, and ignore the differences. This is particularly true for the recent series of fMRI studies that have reported shared neural circuits for the first-hand experience of pain and the perception of pain in others (see Jackson, Rainville, & Decety, 2006, for an exception). It is, however, possible, as argued by Zaki and collaborators, that common activity in ACC and AI may reflect the operation of distinct but overlapping networks of regions that support perception of self or other-pain. To address this issue, they scanned participants while they received noxious thermal stimulation (self-pain condition) or watched short videos of other people sustaining painful injuries (other-pain condition). Analyses identified areas whose activity covaried with ACC and AI activity during self or other-pain either across time (intra-individual connectivity) or across participants (inter-individual connectivity). Both connectivity analyses identified clusters in the midbrain and periaqueductal gray with greater connectivity to the AI during self-pain as opposed to other-pain. The opposite pattern was found in the dorsal medial prefrontal cortex, which showed greater connectivity to the ACC and AI during other-pain than during self-pain using both types of analysis. Intra-individual connectivity analyses also revealed regions in the superior temporal sulcus, posterior cingulate, and precuneus that became more connected to ACC during other-pain as compared to self-pain. The results of this experiment document distinct neural networks associated with ACC and anterior insula in response to first-hand experience of pain and response to seeing other people in pain. These networks could not have been detected in prior work that examined overlap between self- and other-pain in terms of average activity, but not connectivity.

Lawrence and colleagues investigated affective and cognitive empathy with a series of self-report measures in individuals diagnosed with depersonalisation disorder (DPD), who report various disturbances related to "body image" such as feelings of "disembodiment" and "emotional numbing." In addition, they measured participants' tendency to rely on knowledge about themselves when attributing affective states to other people. As predicted, the DPD group showed intact performance on the task tapping cognitive empathy, alongside a disruption in affective empathy as evident from speech rate patterns. These data were also indicative of an over reliance by the DPD group on information relating to the self when attributing affective states to other people. The findings suggest that affective empathy is an embodied state that can be disrupted by changes in body image.

It is believed that disorganized attachment is an early predictor of development of psychopathology in childhood and adolescence. Gervai and colleagues previously had found an association between polymorphism of the *DRD4* gene and disorganized attachment, and in the present study, they investigated the interplay between genetic and care giving contributions to disorganized attachment. A total of 138 mother–infant dyads, 96 from a Hungarian low-social-risk sample and 42 from a US high-social-risk sample, were assessed for infant disorganized attachment behavior, for *DRD4* gene polymorphisms, and for disrupted forms of maternal affective communication with the infant. In accord with literature reports, the authors found a robust main effect of maternal AMBIANCE scores on infant disorganization. However, this relation held only for the majority of infants who carried the short form of the DRD4 allele. Among carriers of the 7-repeat DRD4 allele, there was no relation between quality of maternal communication and infant disorganization. This interaction effect was independent of degree of social risk and maternal *DRD4* genotype. These results suggest that the 7-repeat DRD4 allele reduces sensitivity to maternal affective communication.

Hobson, Lee, and Meyer elaborate a theoretical position and report an empirical study on a specific form of interpersonal engagement: the propensity to identify with the subjective orientation of another person. On the basis of a hypothesis that individuals with autism have a relative lack of this form of intersubjective connectedness, they predicted that children and adolescents with autism would contrast with matched participants without autism in specific aspects of communication when requested to "Get Pete to do this" after witnessing an adult demonstrating actions in Pete's absence. As predicted, on blind ratings of videotapes of participants' communication, those with autism achieved lower scores on four indices of identification that were selected a priori: emotional engagement, sharing experience in joint attention, communication of style, and shifting in communicative role. The two groups were almost completely separate on a composite measure of identification. Hobson et al. consider the implications of these findings for typical and atypical development.

One of the most complex and perplexing aspects of human interpersonal sensitivity is its links with moral reasoning. Recently cognitive neuroscience has begun to explore the neural underpinning of such complex behavior. Moll and his colleagues have argued that moral sensitivity depends on a sophisticated integration of cognitive, emotional, and motivational mechanisms that are modulated by individual experience in different cultural milieus. Different lines of investigation on agency and morality have pointed to overlapping neural systems. In the present research, Moll et al. used functional MRI to investigate the contribution of agency to brain activation by manipulating elicitors of specific moral emotions, such as interpersonal harm. Results showed that emotionally neutral agency recruited neural networks previously associated with agency, intentionality and moral cognition, encompassing ventral and subgenual sectors of the medial prefrontal cortex (PFC), insula, anterior temporal cortex and superior temporal sulcus (STS). Compared to emotionally neutral agency, different categories of moral emotions led to distinct activation patterns: (1) prosocial emotions (guilt, embarrassment, compassion) activated the anterior medial PFC and STS; with (2) empathic emotions (guilt and compassion) additionally recruiting the mesolimbic pathway; (3) other-critical emotions (disgust and indignation) were associated with activation of the amygdala—parahippocampal and fusiform areas. These findings indicate that agency related to norm-abiding social behaviors of emotionally neutral scripts share neural substrates both with the "default mode" of brain function and with the moral sensitivity network. Additional activation in specific components of this network is elicited by different classes of moral emotions, in agreement with recent integrative models of moral cognition and emotion.

Philosopher of mind Shawn Gallagher present critical arguments against both explicit and implicit versions of the simulation theory for intersubjective understanding. He contends that logical, developmental, and phenomenological evidence counts against explicit simulation if this is understood as the pervasive or default way that we understand others. Implicit (subpersonal) simulation, identified with neural resonance systems (mirror systems or shared representations), fails to provide the kind of simulation required by simulation theory, because it fails to explain how neuronal processes meet constraints that involve instrumentality and pretense. Implicit simulation theory also fails to explain how one can attribute a mental or emotion state that is different from one's own to another person. Building on his analysis, Gallagher sketches an alternative interpretation of neural resonance systems.

THEORETICAL ISSUES HIGHLIGHTED BY THE CONTRIBUTIONS

In addressing various aspects of interpersonal knowledge and interpersonal sensitivity, these contributions highlight a number of important theoretical issues. First, and perhaps most pressing, is the question of to what degree ''shared'' neural representations reflect automatic, bottom-up perceptual processes, and to what degree they reflect more constructive, top-down cognitive processes. For example, imagine seeing someone wince when receiving an electric shock. To what degree does this perception (a) directly activate regions of the brain associated with the affective experience of and response to pain, and then (b) this activation lead to cognitive understanding that the other is in pain? Alternatively, to what degree does this perception (a) lead to initial cognitive understanding that the other is in pain, which then (b) recruits regions associated with the affective experience of pain as part of a full understanding/appreciation of the other's pain? If the former occurs, can we feel another's pain without knowing the other is in pain? If the latter occurs, can the recruitment of regions associated with the affective experience of pain be regulated? Can we recognize but not fully understand/appreciate/care that another is in pain (e.g., someone we do not like)? Implicit in these questions is the more basic question of what ''automatic'' means when applied to psychological processes. Does it mean unconscious, inevitable, invariant, unmediated, unmoderated, effortless, self-moving, self-regulating, or something else?

Several of the contributions give attention to individual-difference or situational qualifiers of one or more aspects of interpersonal sensitivity. In the future, attention to such qualifiers will likely increase, raising more questions about how direct and automatic the various aspects of interpersonal sensitivity are.

Second, is there one basic or primary way we come to know how others think and feel? Or, when available, do we make use of multiple channels of information (including, perhaps, motor mimicry, facial mimicry, simulation, knowledge of the other's personality and values, knowledge of the other's situation, knowledge of what others have thought and felt in similar situations, knowledge of how we have thought and felt in similar situations, and perspective-taking/imagination)?

Third, how shared are ''shared representations''? It is known that regions associated with the affective experience of pain (ACC and AI) are activated both during one's own experience of pain (self-pain) and when witnessing another in pain (other-pain). But does this common activation reflect the same experience of pain? Might one be pained for (distressed for) another in pain but directly pained (distressed) at one's own pain? If so, are the two experiences of pain embedded in distinct neural constellations or networks that lead to them being experienced as psychologically distinct emotions? Might the experience of pain in each case involve activation of regions associated with intention and desire, yet the intentions and desires be different in the two cases (relief of the other's suffering; relief of one's own suffering)? Does the level and character of other-pain change depending on one's personality, one's relation to the other, the relevance of the other's welfare to one's own, or prior experience in situations like the other's?

Finally, what is the role of self–other merging and self–other distinctiveness in interpersonal sensitivity? Do mimicry, mirroring, perception–action overlap, or some combination of these, merge the experience of the other with one's own experience? Or, even in these ''shared'' processes, does the awareness of whose experience is whose remain clear? That is, when a person reacts emotionally on witnessing someone else react emotionally, is there a loss of self–other distinctiveness, or is self–other distinctiveness maintained—and possibly even heightened?

We are just at the beginning of a long journey in search of answers to these and other questions about the nature of interpersonal sensitivity. The contributions to this special issue have helped get us off to a good start. They have also helped us to see some of the conceptual and methodological thickets that lie ahead. The journey will not be easy, but it promises to be exciting. Indeed, the contributions show how exciting it already is.

Interpersonal sensitivity, and social interaction more broadly, involve a complex interplay of personality and situational factors. One of the challenges for a social neuroscience approach to interpersonal sensitivity is the difficulty of taking into account situational variables. To provide interpretable data, neuroscience experiments require intra-individual comparisons and repeated-measures designs. To be financially feasible, they require small samples. These conditions limit opportunities to study the effects of potentially important situational variables.

This is but one example of the perennial challenge objective science faces in the attempt to understand human subjectivity in all its richness and complexity.

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