doi:10.1093/scan/nst107

Editorial

Dynamic functional integration of distinct neural empathy systems

Recent evidence points to two separate systems for empathy: a vicarious sharing emotional system that supports our ability to share emotions and mental states and a cognitive system that involves cognitive understanding of the perspective of others. Several recent models offer new evidence regarding the brain regions involved in these systems, but no study till date has examined how regions within each system dynamically interact. The study by Raz *et al*. in this issue of *Social, Cognitive, & Affective Neuroscience* is among the first to use a novel approach of functional magnetic resonance imaging analysis of fluctuations in network cohesion while an individual is experiencing empathy. Their results substantiate the approach positing two empathy mechanisms and, more broadly, demonstrate how dynamic analysis of emotions can further our understanding of social behavior.

One of the fundamental empathy-related questions is whether empathy is an emotional affective or a cognitive concept. Whereas the capacity to experience affective reactions to the observed experiences of others or to share a 'fellow feeling' has been described as 'emotional empathy', the concept of cognitive empathy describes the cognitive process of adopting another's psychological point of view. Recent evidence from the field of social neuroscience has proven essential in characterizing the neural basis of empathy, thus providing new insights into these questions. Converging evidence supports a model of two separate systems for empathy: an emotional system and a cognitive system. The study by Raz *et al.* (2013) addresses the process of emotional empathy as involving not only affective information, but also more basic embodied simulation (ES). ES is defined as a bottom–up automatic process that involves the vicarious sharing of the bodily states of others and is linked to a set of brain regions, among them the inferior frontal gyrus (IFG) that is associated with the mirror neurons system as well as the anterior insula (AI) and the middle anterior cingulate (ACC). On the other hand, cognitive empathy is defined in this study as a more top–down system that allows the making of inferences regarding the mental state of others (e.g. theory of mind: ToM). This system is associated with a series of brain regions, including the ventral and dorsal aspects of the medial prefrontal (MPF) cortex, the superior temporal sulcus and the temporo-parietal junction (TPJ).

In this issue of ***Social, Cognitive, & Affective Neuroscience***, Raz *et al.* report on a new study showing not only that empathy is indeed mediated by these two different series of brain regions, but also that regions within each system interact dynamically and corresponds with the intensity of reported empathic feelings. Thus far, neuroimaging studies have identified several brain regions as being involved in empathy, but only a handful of studies have examined connectivity between these regions. Furthermore, till date no study has examined the developing dynamics of the functional connectivity between these regions during an empathy-provoking situation. Thus, the main strength of the study lies in its use of an innovative methodological approach to identify how regions within the ES and the ToM networks interact during different empathy-eliciting situations. According to the theoretical framework presented in this study, the synchrony or coherence of brain activities changes dynamically during emotional experiences, so that characterizing the dynamics of connectivity within and between functional networks may provide important information regarding empathy-related processes.

In this study, empathy was provoked by showing participants two scenes that depict a dramatic development in the plot of two well-known films [*Stepmom* (Columbus, 1998); *Sophie's Choice* (Pakula, 1982)]. Both are extremely distressing scenes depicting a mother being separated from her children. To examine how empathy dynamically changes throughout the scenes, the authors developed a data analysis method based on functional magnetic resonance imaging, which calculates an index based on the strength and distribution of the correlations between regions within a defined neural network. This cohesion index allows the intensity of the interactions between regions in a network to be characterized over time. Thus, patterns of connectivity within both the ES and the ToM networks were examined, as was the connectivity between these networks and limbic regions. Specifically, the authors speculated that the cohesion index would be higher in the ES and ToM networks depending on the empathy-provoking situation and that the connectivity within these networks as well as their links to limbic structures, would be modulated by the intensity of the behavioral ratings of the empathy experienced during film viewing.

The findings of Raz *et al.* support the notion that ES- and ToM-related sets of regions actually function as networks. Importantly, the results show that inter-regional crosstalk may increase as individuals become empathically engaged. Moreover, the authors demonstrate that the cohesion index within the ToM network is positively linked with the behavioral empathy ratings in *Stepmom*, but negatively correlated with the cohesion index in *Sophie's Choice*. On the other hand, the correlations between the behavioral empathy measures in *Sophie's Choice* and the ES-limbic-index are positively significant.

The discrepancy between the findings for *Sophie's Choice* and those for *Stepmom* may represent distinct aspects of empathy. It appears that although both scenes in the films involve social distress associated with separation, they differ along many other contextual dimensions, among them vividness, levels of distress and emotionality. The situation in *Sophie's Choice* depicts a mother who was forced by a Nazi officer to choose which of her two children would be sent to death, while in the clip from *Stepmom*, a mother talks separately with each of her children about her own impending death from a terminal disease. Thus, the scene in *Sophie's Choice* appears to depict an immediate and

Received 30 June 2013; Accepted 16 July 2013
Advance Access publication 16 August 2013
Correspondence should be addressed to Simone G. Shamay-Tsoory, Department of Psychology, University of Haifa, Mount Carmel, Haifa 31905 Israel. E-mail: sshamay@psy.haifa.ac.il

vivid intense emotional separation, while the *Stepmom* scene involves discussions about a future separation.

The association between the behavioral empathy measures in *Sophie's Choice* and the ES-limbic-index may indicate that intense distressful scenarios such as abrupt separation and immediate threat of death trigger emotional empathy processing. These scenarios may elicit state-matching reactions associated with neural mechanisms of matching, such as mirror neurons system (MNS) activities that have been identified in the IFG (Brodmann's Area [BA]45/44/6). The IFG has been suggested as a mechanism that identifies the goals or intentions of actions according to their resemblance to stored representations of these actions (Rizzolatti *et al.*, 2009). The existence of mirror neurons related to emotional facial expressions in the human IFG suggests that the human MNS may be used to convert observed facial expressions into a pattern of neural activity that would be suitable for producing similar facial expressions and would provide the neural basis for emotional contagion (Keysers and Gazzola, 2006).

Furthermore, the ES system includes other core regions such as the ACC and AI that have been associated with the experience of shared pain. The scene from *Sophie's Choice* that shows a mother's realization that one of her sons is being sent to death involves the extreme social pain of separation. Empathy for pain has been repeatedly shown to involve regions related to the first-hand experience of pain, such as parts of the pain matrix. Specifically, a network including the anterior ACC and the AI was reported to respond both to felt and to observed pain (Decety, 2010). Moreover, considering that a growing body of literature has suggested a possible overlap in the neural circuitry underlying physical and social pain (Eisenberger, 2012), it is possible that the correlations between the behavioral empathy measures for the scene from *Sophie's Choice* and the ES-limbic-index reflect increased connectivity within a shared social pain network.

While the scene from *Sophie's Choice* was associated with increased cohesion in the ES system, the cohesion index within the ToM network was *positively* linked with the behavioral empathy ratings in *Stepmom*. As mentioned above, the scene from *Stepmom* involved a potential separation in the future, possibly indicating that increased cohesion between regions in this network may play a role in reflection about the future. Indeed, cumulative data suggest that self-projection (the ability to shift perspective from the immediate present to alternative perspectives), remembering the past and ToM are based on the same core brain networks (Buckner and Carroll, 2007), suggesting that these processes share similar mechanisms. It has been suggested that a neural network involving the MPF is crucial for remembering the past but also serves to provide building blocks for self-projection and future simulation (Schacter *et al.*, 2007). Thus, one plausible hypothesis that emerges from this study is that ToM relies on a common set of processes by which thinking about the future is used to understand events happening to others.

Furthermore, one of the elementary prerequisites for ToM is the basic distinction between actions generated by the self and those generated by others (Mitchell, 2009). Although the self–other distinction is also required in emotional empathy, it appears that during higher level inference-based processes, a network involving the MPF and the TPJ is responsible for shared representations of self and other (Zaki and Ochsner, 2012). Thus, it appears that the *Stepmom* scene, which depicts a top–down higher level of inference regarding future-based information, requires high levels of self–other distinction.

Collectively, the findings of the study by Raz *et al.* serve as an excellent first step toward understanding the neural systems underlying the experience of real-time empathy. It appears that not only does the authors' novel approach for analyzing the dynamics of functional network connectivity provides further support for the dissociation between the two empathy networks, it also suggests that these circuits may be dynamically recruited, depending on the circumstances under which empathy is experienced.

These findings may also imply that psychiatric and neurological disorders that involve diminished empathy may originate not only from a dysfunction of localized regions within these networks, but perhaps may also emerge from impaired dynamism and connectivity within these networks.

Finally, in line with social neuroscience's growing emphasis on the need to move from a single brain to a multibrain frame of reference (Hasson *et al.*, 2012), future studies involving real-time brain-to-brain techniques such as hyperscanning measures may extend these initial efforts and examine the dynamic of synchrony between two (or more) interacting brains. Applying the novel technique proposed by Raz *et al.* together with new interbrain approaches may provide an opportunity for further exploring the neural dynamics of social behavior.

Conflict of Interest

None declared.

Simone G. Shamay-Tsoory
Department of Psychology, University of Haifa,
Mount Carmel, Haifa 31905 Israel

REFERENCES

Buckner, R.L., Carroll, D.C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences*, *11*, 49–57.

Columbus, C. (1998). *Stepmom*. Culver City, CA: Sony Pictures.

Decety, J. (2010). The neurodevelopment of empathy in humans. *Developmental Neuroscience*, *32*, 257–67.

Eisenberger, N.I. (2012). The pain of social disconnection: examining the shared neural underpinnings of physical and social pain. *Nature Reviews Neuroscience*, *13*(6), 421–34.

Hasson, U., Ghazanfar, A.A., Galantucci, B., Garrod, S., Keysers, C. (2012). Brain-to-brain coupling: a mechanism for creating and sharing a social world. *Trends in Cognitive Science*, *16*(2), 114–21.

Keysers, C., Gazzola, V. (2006). Towards a unifying neural theory of social cognition. *Progress in Brain Research*, *156*, 379–401.

Mitchell, J.P. (2009). Inferences about mental states. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1521), 1309–16.

Pakula, A.J. (1982). *Sophie's Choice*. Incorporated Television Company (ITC).

Raz, G., Jacob, Y., Gonen, T., et al. (2013). Cry for her or cry with her: Context-dependent dissociation of two modes of cinematic empathy reflected in network cohesion dynamics. *Social Cognitive and Affective Neuroscience*, *9*, 30–38.

Rizzolatti, G., Fabbri-Destro, M., Cattaneo, L. (2009). Mirror neurons and their clinical relevance. *Nature Clinical Practice Neurology*, *5*(1), 24–34.

Schacter, D.L., Addis, D.R., Buckner, R.L. (2007). Remembering the past to imagine the future: the prospective brain. *Nature Reviews Neuroscience*, *8*(9), 657–61.

Zaki, J., Ochsner, K. (2012). The neuroscience of empathy: progress, pitfalls and promise. *Nature Neuroscience*, *15*, 675–80.