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Neural mechanisms of social cognition – the mirror neuron system and beyond

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In my PhD thesis, I present three functional magnetic resonance imaging studies aimed at investigating neurobiological mechanisms underlying social cognition. My thesis focuses on fast and automatic processes that are proposed to build the basis of social understanding, and might be activated in parallel to more effortful deliberate mechanisms. The proposed neural substrate of fast and automatic processes are mirror neurons, which according to the theory of embodied simulation allow humans to understand other individuals' actions, and even emotions and intentions. Since non-invasive techniques cannot be applied to measure mirror neurons, but only neural populations assumed to constitute the mirror neuron system, experimental paradigms and analysis routines that allow approximation of mirror neuron functions need to be developed.
In study 1, I demonstrated that different social cognitive skills, including imitation, affective empathy and theory of mind share a common neural basis, located in regions associated with the mirror neuron system. In addition to standard analyses, a shared voxel analysis was applied that revealed common activation for social-cognitive processes not only across, but also within participants.
Study 2 was set up to investigate whether the mirror neuron system can distinguish the valence of facial configurations. The use of a functional magnetic resonance imaging adaptation paradigm allowed to determine neural populations sensitive to emotional valence. While the fusiform gyrus was sensitive to changes from fearful to smiling faces and also from smiling to fearful faces, Brodmann area 44 reaching into insula, and superior temporal sulcus, i.e. regions more commonly associated with the mirror neuron system and with the so called mentalizing network, showed particularly increased activation for switches from smiling to fearful faces.
Study 3 was dedicated to the investigation of decision making in the context of ambiguous facial configurations. While probabilistic decision making on these facial configurations lead to activation in the executive control network, final decisions for an emotion resulted in nucleus accumbens activation. In addition, perceiving fear in a face lead to higher nucleus accumbens activation during final decisions than perceiving happiness. This finding can be linked to salience processing in the nucleus accumbens.
In conclusion, all three studies show an involvement of fast and automatic processing regions for different social-cognitive processes. Study 3 additionally examined the interaction with slower and more deliberate processes, as involved in probabilistic decision making on ambiguous faces. The mirror neuron system seems to be critically involved in different social-cognitive tasks and also sensitive to emotional valence. In cases when automatic processing is not possible, as when presented with ambiguous facial configurations, brain regions commonly associated with probabilistic decision making assist, and the nucleus accumbens, possibly by directing salience, is involved in the final decision. These results deepen the understanding of the mechanisms of social cognition and encourage the use of sophisticated methods in experimental paradigms and analysis.