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Social Cognitive Neuroscience

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People spend a lot of their brain energy thinking about people. Social cognitive neuroscience is the field of research that investigates how this works. Research in this field asks questions about the brain regions people use when thinking about people, the computations that occur in these brain regions, how these regions and computations develop, and how they vary between people with different cultural backgrounds. Progress on these questions accelerated dramatically when functional magnetic resonance imaging (fMRI) became relatively widely available. People can read or listen to stories, watch TV shows or movies, or play interactive games all while their brains are scanned. Activity in many different brain regions is evoked by these social activities, including brain regions linked to perception, attention, and reward processing. The focus of social cognitive neuroscience studies, however, is typically on brain regions or computations that are distinctively social, occurring selectively when thinking about people.

History

Before fMRI existed, three kinds of evidence suggested that social cognition might depend on distinct brain systems.

First, patients with brain injury or disease sometimes lose their social graces first and fastest. For example, in one type of dementia, the first symptoms include becoming emotionally insensitive, socially inappropriate, and losing empathy for loved ones ([Cerami & Cappa, 2013](#); [Adolphs, 1999](#)).

Second, in animals, distinct neural systems are necessary for normal social relationships. When scientists created damage in specific brain regions, for example, the amygdala in a macaque monkey, the monkey remained physically and emotionally competent but became socially incompetent ([Aggleton & Passingham, 1981](#); [Machado & Bachevalier, 2006](#)).

Third, children diagnosed with autism struggled to solve problems about other minds [see [Autism](#)]. In the early 1980s, the ‘false belief test’ was invented as a way to measure thinking about thought (first in chimpanzees, later in children) [see [Theory of Mind](#)]. Autistic children failed the false belief test, even when they could solve equally hard reasoning puzzles with no social content ([Baron-Cohen et al., 1985](#)). This pattern of performance implied that autism could impair social computations in the brain, disproportionately to its effects on other computations, and, therefore, that social computations might be segregated or special.

In light of these three kinds of evidence, when fMRI became available, the first social cognitive neuroscience experiments looked for brain regions that play a distinctive role in empathy ([Singer et al., 2004](#)) and false belief tasks ([Gallagher et al., 2000](#)).

Core concepts

Empathy

Empathy is a vicarious, usually negative, emotion: feeling bad because of someone else's suffering. Psychological research has identified two different flavors of empathy: (i) *sharing* the other person's suffering and experiencing a similar negative emotion versus (ii) *caring* about the other person's suffering and experiencing compassion toward them. This distinction corresponds well to different patterns of brain activity ([Preckel et al., 2018](#)). Sharing someone's pain evokes brain activity similar to directly experiencing pain. Caring about someone's pain evokes different brain activity, including in medial prefrontal cortex (MPFC; see below).

Theory of mind, or mentalizing

Initially studied using false belief tasks, *theory of mind* and *mentalizing* refer to the cognitive process of reasoning about another person's thoughts. This process is invoked for explaining their past actions, predicting their future actions, and making moral evaluations. One brain region that plays a key role in this process is located in the right temporo-parietal junction (RTPJ; [Saxe & Kanwisher, 2003](#)). Diagnostic spatial patterns of activity arise in RTPJ when thinking about a hurtful action that was accidental versus intentional ([Koster-Hale et al., 2013](#)). Transiently disrupting the patterns of activity in RTPJ, using transcranial magnetic stimulation alters these judgments, making accidents seem more wrong ([Young et al., 2010](#)). Some studies find that autistic people have altered RTPJ function (e.g., [Bravo Balsa et al., 2024](#), but see [Dufour et al., 2013](#)).

Medial prefrontal cortex

On the middle surface of the brain, where the two cortical hemispheres lie pressed against one another, activity peaks during many different social activities, like watching the climax of a movie ([Chang et al., 2021](#)), reading an emotionally loaded story ([Shamay-Tsoory et al., 2006](#)), or sharing a moment face-to-face with a friend ([Misaki et al., 2021](#); [Redcay & Schilbach, 2019](#)). The amount of activity predicts later social motivations like wanting to help or engage ([Grossman & Allison, 2024](#); [Waytz et al., 2012](#)). Activity also peaks in the MPFC when a person reflects on themselves ([Jenkins & Mitchell, 2011](#)), for example, about the kind of person they aspire to be ([Cascio et al., 2016](#)), a process that is particularly important in adolescent development ([Somerville et al., 2013](#); [van der Crujsen et al., 2023](#)). Plus, the MPFC has unusually high activity when people are just lying in the scanner, letting their minds wander ([Meyer, 2019](#)). It remains controversial how these different functions of MPFC are related to one another, either conceptually or in their layout on the cortical surface ([Denny et al., 2012](#); [Lieberman et al., 2019](#); [Molenberghs et al., 2016](#)).

Questions, controversies, and new developments

Is there a uniquely human kind of social cognition? Although all social animals use social skills to coordinate, cooperate, and compete with conspecifics, human social cognition seems to be supersized, for example in communication, pedagogy, and moral judgment. Ongoing research on this question addresses whether humans have evolved entirely distinct brain networks for social cognition or whether

they have expanded and repurposed the social brain networks of other primates ([Deen et al., 2023](#); [Isoda, 2021](#)).

How do social brain functions change during human development? Just hours after birth, human neonates prefer to look at faces and recognize their own mother, but the sophistication of social cognition changes dramatically over development, in infancy and childhood and through adolescence [see [Cognitive Development](#); [Social Learning](#)]. Further debates that shape the field of social cognitive neuroscience include whether infants are born with an innately “social” brain ([Grossman, 2013](#); [2015](#)) and whether and how changes in the brain explain changes in social capacities ([Richardson et al., 2018](#)).

Broader connections

Social cognition is not limited to one person thinking about one other person. People recognize groups and value group identities. The associated brain activity is investigated in a subfield of social cognitive neuroscience called intergroup neuroscience ([Cikara & Van Bavel, 2014](#); [Jenkins et al., 2018](#)). For example, people care more about strangers who share a group identity and correspondingly show more empathy-related brain activity in response to their suffering. The suffering of people from threatening competitor groups can even generate the opposite pattern, activity in brain regions associated with reward. Intergroup neuroscientists study the brain processes that happen when we humanize some people and dehumanize others ([Fiske, 2009](#); [Amodio & Cikara, 2021](#)).

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Further reading

- Grossmann, T., & Allison, O. (2024). Dorso-medial prefrontal cortex responses to social smiles predict sociability in early human development. *Imaging Neuroscience*, 2, 1–8. https://doi.org/10.1162/imag_a_00129
- Lockwood, P. L., Apps, M. A. J., & Chang, S. W. C. (2020). Is there a ‘social’ brain? Implementations and algorithms. *Trends in Cognitive Sciences*, 24(10), 802–813. <https://doi.org/10.1016/j.tics.2020.06.011>
- Koster-Hale, J., & Saxe, R. (2013). Theory of mind: A neural prediction problem. *Neuron*, 79(5), 836–848. <https://doi.org/10.1016/j.neuron.2013.08.020>

References

- Adolphs, R. (1999). Social cognition and the human brain. *Trends in Cognitive Sciences*, 3(12), 469–479. [https://doi.org/10.1016/S1364-6613\(99\)01399-6](https://doi.org/10.1016/S1364-6613(99)01399-6)
- Aggleton, J. P., & Passingham, R. E. (1981). Syndrome produced by lesions of the amygdala in monkeys (*Macaca mulatta*). *Journal of Comparative and Physiological Psychology*, 95(6), 961–977.

<https://doi.org/10.1037/h0077848>

↵

- Amodio, D. M., & Cikara, M. (2021). The social neuroscience of prejudice. *Annual Review of Psychology*, 72, 439–469. <https://doi.org/10.1146/annurev-psych-010419-050928>

↵

- Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a “theory of mind”? *Cognition*, 21(1), 37–46. [https://doi.org/10.1016/0010-0277\(85\)90022-8](https://doi.org/10.1016/0010-0277(85)90022-8)

↵

- Bravo Balsa, L., Abu-Akel, A., & Mevorach, C. (2024). Dynamic functional connectivity in the right temporoparietal junction captures variations in male autistic trait expression. *Autism Research*, 17(4), 702–715. <https://doi.org/10.1002/aur.3117>

↵

- Cascio, C. N., O'Donnell, M. B., Tinney, F. J., Lieberman, M. D., Taylor, S. E., Strecher, V. J., & Falk, E. B. (2016). Self-affirmation activates brain systems associated with self-related processing and reward and is reinforced by future orientation. *Social Cognitive and Affective Neuroscience*, 11(4), 621–629. <https://doi.org/10.1093/scan/nsv136>

↵

- Cerami, C., & Cappa, S. F. (2013). The behavioral variant of frontotemporal dementia: Linking neuropathology to social cognition. *Neurological Sciences*, 34, 1267–1274. <https://doi.org/10.1007/s10072-013-1317-9>

↵

- Chang, L. J., Jolly, E., Cheong, J. H., Rapuano, K. M., Greenstein, N., Chen, P.-H. A., & Manning, J. R. (2021). Endogenous variation in ventromedial prefrontal cortex state dynamics during naturalistic viewing reflects affective experience. *Science Advances*, 7(17), Article eabf7129. <https://doi.org/10.1126/sciadv.abf7129>

↵

- Cikara, M., & Van Bavel, J. J. (2014). The neuroscience of intergroup relations: An integrative review. *Perspectives on Psychological Science*, 9(3), 245–274. <https://doi.org/10.1177/1745691614527464>

↵

- Deen, B., Schwiedrzik, C. M., Sliwa, J., & Freiwald, W. A. (2023). Specialized networks for social cognition in the primate brain. *Annual Review of Neuroscience*, 46, 381–401. <https://doi.org/10.1146/annurev-neuro-102522-121410>

↵

- Denny, B. T., Kober, H., Wager, T. D., & Ochsner, K. N. (2012). A meta-analysis of functional neuroimaging studies of self- and other judgments reveals a spatial gradient for mentalizing in medial prefrontal cortex. *Journal of Cognitive Neuroscience*, 24(8), 1742–1752. https://doi.org/10.1162/jocn_a_00233

↩

- Dufour, N., Redcay, E., Young, L., Mavros, P. L., Moran, J. M., Triantafyllou, C., Gabrieli, J. D. E., & Saxe, R. (2013). Similar brain activation during false belief tasks in a large sample of adults with and without autism. *PloS ONE*, 8(9), Article e75468. <https://doi.org/10.1371/journal.pone.0075468>

↩

- Fiske, S. T. (2009). From dehumanization and objectification to rehumanization: Neuroimaging studies on the building blocks of empathy. *Annals of the New York Academy of Sciences*, 1167(1), 31–34. <https://doi.org/10.1111/j.1749-6632.2009.04544.x>

↩

- Gallagher, H. L., Happé, F., Brunswick, N., Fletcher, P. C., Frith, U., & Frith, C. D. (2000). Reading the mind in cartoons and stories: An fMRI study of ‘theory of mind’ in verbal and nonverbal tasks. *Neuropsychologia*, 38(1), 11–21. [https://doi.org/10.1016/S0028-3932\(99\)00053-6](https://doi.org/10.1016/S0028-3932(99)00053-6)

↩

- Grossmann, T. (2013). The role of medial prefrontal cortex in early social cognition. *Frontiers in Human Neuroscience*, 7, Article 340. <https://doi.org/10.3389/fnhum.2013.00340>

↩

- Grossmann, T. (2015). The development of social brain functions in infancy. *Psychological Bulletin*, 141(6), 1266–1287. <https://doi.org/10.1037/bul0000002>

↩

- Grossmann, T., & Allison, O. (2024). Dorso-medial prefrontal cortex responses to social smiles predict sociability in early human development. *Imaging Neuroscience*, 2, 1–8. https://doi.org/10.1162/imag_a_00129

↩

- Isoda, M. (2021). The role of the medial prefrontal cortex in moderating neural representations of self and other in primates. *Annual Review of Neuroscience*, 44, 295–313. <https://doi.org/10.1146/annurev-neuro-101420-011820>

↩

- Jenkins, A. C., & Mitchell, J. P. (2011). Medial prefrontal cortex subserves diverse forms of self-reflection. *Social Neuroscience*, 6(3), 211–218. <https://doi.org/10.1080/17470919.2010.507948>

↩

- Jenkins, A. C., Karashchuk, P., Zhu, L., & Hsu, M. (2018). Predicting human behavior toward members of different social groups. *Proceedings of the National Academy of Sciences*, 115(39), 9696–9701. <https://doi.org/10.1073/pnas.1719452115>

↩

- Koster-Hale, J., Saxe, R., Dungan, J., & Young, L. L. (2013). Decoding moral judgments from neural representations of intentions. *Proceedings of the National Academy of Sciences*, 110(14), 5648–5653. <https://doi.org/10.1073/pnas.1207992110>

↩

- Lieberman, M. D., Straccia, M. A., Meyer, M. L., Du, M., & Tan, K. M. (2019). Social, self, (situational), and affective processes in medial prefrontal cortex (MPFC): Causal, multivariate, and reverse inference evidence. *Neuroscience & Biobehavioral Reviews*, 99, 311–328. <https://doi.org/10.1016/j.neubiorev.2018.12.021>

↩

- Machado, C. J., & Bachevalier, J. (2006). The impact of selective amygdala, orbital frontal cortex, or hippocampal formation lesions on established social relationships in rhesus monkeys (*Macaca mulatta*). *Behavioral Neuroscience*, 120(4), 761–786. <https://doi.org/10.1037/0735-7044.120.4.761>

↩

- Meyer, M. L. (2019). Social by default: Characterizing the social functions of the resting brain. *Current Directions in Psychological Science*, 28(4), 380–386. <https://doi.org/10.1177/0963721419857759>

↩

- Misaki, M., Kerr, K. L., Ratliff, E. L., Cosgrove, K. T., Simmons, W. K., Morris, A. S., & Bodurka, J. (2021). Beyond synchrony: The capacity of fMRI hyperscanning for the study of human social interaction. *Social Cognitive and Affective Neuroscience*, 16(1-2), 84–92. <https://doi.org/10.1093/scan/nsaa143>

↩

- Molenberghs, P., Johnson, H., Henry, J. D., & Mattingley, J. B. (2016). Understanding the minds of others: A neuroimaging meta-analysis. *Neuroscience & Biobehavioral Reviews*, 65, 276–291. <https://doi.org/10.1016/j.neubiorev.2016.03.020>

↩

- Preckel, K., Kanske, P., & Singer, T. (2018). On the interaction of social affect and cognition: Empathy, compassion and theory of mind. *Current Opinion in Behavioral Sciences*, 19, 1–6. <https://doi.org/10.1016/j.cobeha.2017.07.010>

↩

- Redcay, E., & Schilbach, L. (2019). Using second-person neuroscience to elucidate the mechanisms of social interaction. *Nature Reviews Neuroscience*, 20(8), 495–505. <https://doi.org/10.1038/s41583-019-0179-4>

↩

- Richardson, H., Lisandrelli, G., Riobueno-Naylor, A., & Saxe, R. (2018). Development of the social brain from age three to twelve years. *Nature Communications*, 9(1), Article 1027. <https://doi.org/10.1038/s41467-018-03399-2>

↩

- Saxe, R., & Kanwisher, N. (2003). People thinking about thinking people: The role of the temporo-parietal junction in “theory of mind.” *NeuroImage*, 4(19), 1835–1842. [https://doi.org/10.1016/S1053-8119\(03\)00230-1](https://doi.org/10.1016/S1053-8119(03)00230-1)

↩

- Shamay-Tsoory, S. G., Tibi-Elhanany, Y., & Aharon-Peretz, J. (2006). The ventromedial prefrontal cortex is involved in understanding affective but not cognitive theory of mind stories. *Social Neuroscience*, 1(3-4), 149–166. <https://doi.org/10.1080/17470910600985589>

↩

- Singer, T., Seymour, B., O’Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science*, 303(5661), 1157–1162. <https://doi.org/10.1126/science.1093535>

↩

- Somerville, L. H., Jones, R. M., Ruberry, E. J., Dyke, J. P., Glover, G., & Casey, B. J. (2013). The medial prefrontal cortex and the emergence of self-conscious emotion in adolescence. *Psychological Science*, 24(8), 1554–1562. <https://doi.org/10.1177/0956797613475633>

↩

- van der Crujssen, R., Blankenstein, N. E., Spaans, J. P., Peters, S., & Crone, E. A. (2023). Longitudinal self-concept development in adolescence. *Social Cognitive and Affective Neuroscience*, 18(1), Article nsac062. <https://doi.org/10.1093/scan/nsac062>

↩

- Waytz, A., Zaki, J., & Mitchell, J. P. (2012). Response of dorsomedial prefrontal cortex predicts altruistic behavior. *Journal of Neuroscience*, 32(22), 7646–7650. <https://doi.org/10.1523/JNEUROSCI.6193-11.2012>

↩

- Young, L., Camprodon, J. A., Hauser, M., Pascual-Leone, A., & Saxe, R. (2010). Disruption of the right temporoparietal junction with transcranial magnetic stimulation reduces the role of beliefs in moral judgments. *Proceedings of the National Academy of Sciences*, 107(15), 6753–6758.
<https://doi.org/10.1073/pnas.0914826107>

[↩](#)