CellPress

Trends in
Cognitive Sciences

Letter

Abstract social interaction representations along the lateral pathway

Emalie McMahon[1] and
Leyla Isik[1,2,*]

Recent work in vision science and visual neuroscience has moved away from focusing on single people or objects to understanding the relations between them. Based on converging behavioral, computational, and neuroscience evidence, we recently argued that the visual system contains rich, abstract representations of social interactions between others [1]. We also outlined a framework for how this may be implemented in the human brain hierarchically [1], beginning with detecting agents, processing their physical relations, and finally recognizing their social interactions. As part of this framework we argue that mid-level visual features about the physical relations between agents, which we refer to as social primitives, are represented in the extrastriate body area (EBA) and nearby regions of lateral occipitotemporal cortex (LOTC), whereas more abstract information about social interactions is represented in more anterior regions along the superior temporal sulcus (STS). However, Papeo questions our claim that social interaction representations in the STS are, in fact, abstract [2]. We review evidence here that strengthens our claims of a posterior-to-anterior gradient of increasingly abstract representations of social interaction features along the recently proposed lateral visual stream [3] (Figure 1A).

Current evidence has shown that the EBA and nearby regions in LOTC are sensitive to the social primitives of an interaction [4] and possibly to the social interactions themselves [5], although evidence for social interaction representations in LOTC has not been found in all studies (see [4,6] for counterexamples). LOTC has some sensitivity to both static and dynamic stimuli [7] and may contain some information about social interaction category (e.g., arguing vs. celebrating) [8], but representations in LOTC seem to be more perceptual than abstract [4]. Thus, a parsimonious explanation for these results is that representations in EBA and LOTC are an intermediate step to abstract representations in the STS. Indeed, our recent fMRI study using a dense scanning approach with varied naturalistic stimuli provided strong evidence for increasingly abstract representations from LOTC to the STS in individual subjects [4] (Figure 1A).

The STS, unlike EBA, has been found to represent social interactions beyond social primitives across a wide variety of studies and stimuli, from point light displays and interacting animated shapes to cinematic movies [4–6,9]. Further, and counter to Papeo's arguments [2], representations in the STS generalize to novel visual contexts. For instance, social interactions are predictive of STS responses in held-out video stimuli [4] and movie segments [9] that have different low-level visual and motion features. More systematically, one earlier study [6] designed 'helping' and 'hindering' scenarios with drastically different motion trajectories (Figure 1B) and found that representations in the posterior STS generalize to novel 'helping' and

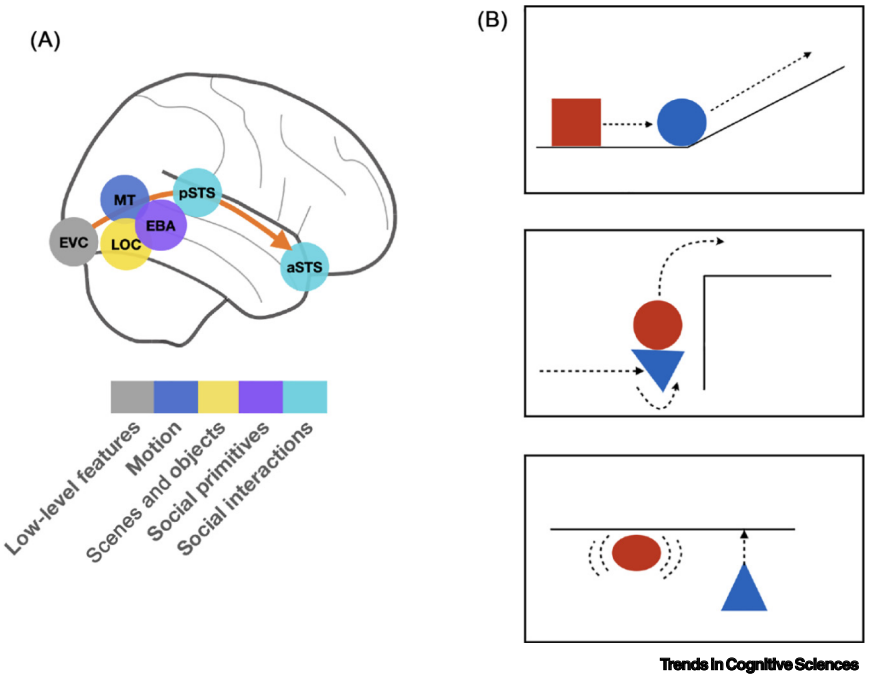

Figure 1. Hierarchy of social interaction representations in the lateral visual stream. (A) Schematic diagram of the lateral visual pathway based on findings from [4]. The pathway projects from early visual regions (early visual cortex, EVC; middle temporal area, MT) which contain representations of low-level visual features, to regions in the lateral occipitotemporal cortex (LOTC), namely the lateral occipital cortex (LOC) and extrastriate body area (EBA) which contain representations for mid-level scene/object and social primitive features, to posterior (p) and anterior (a) superior temporal sulcus (STS) which contain representations for social interactions across a range of different visual stimuli. (B) Representations of help and hinder in the pSTS generalize across different motion trajectories. In addition to the classic 'hill climber' example (top), earlier work has shown that help/hinder distinctions generalize across a range of scenarios; for example, one shape helps another to reach a higher barrier (middle) or escape from an obstacle (bottom). Crucially, a linear classifier trained on pSTS responses to one set of scenarios can also distinguish between helping and hindering in a held-out visual scenario [6].

'hindering' scenarios. Representations in motion-selective middle temporal area (MT) [6], on the other hand, do not generalize to novel scenarios, suggesting that goal compatibility is not confounded with motion congruency in these stimuli. Recent computational work has also provided a mechanism by which these abstract visual representations could be constructed to generalize across motion patterns [10].

Finally, Papeo points out that the STS primarily responds to dynamic social content and asks how its representations can be considered abstract if they do not generalize across static and dynamic scenes [2]. Although this highlights the importance of motion in STS processing, we do not believe that it poses a major challenge to abstract representations in the STS because the overwhelming majority of real-world social interactions are dynamic and recognized based on motion cues.

The above evidence strongly suggests that social visual representations increase in complexity along the lateral visual stream culminating in abstract representations of social interactions in the STS. However, this is a new and emerging research area, and more work will be necessary to characterize the nature of these representations and to understand the neural computations underlying social interaction perception. We agree with Papeo [2] that algorithmically controlled stimuli are a necessary component of this research agenda. However, based on growing evidence that static social stimuli can lead to different theoretical conclusions in both the brain [11] and behavior [12], dynamic and contextually relevant stimuli are crucial for understanding how the mind makes sense of our social world.

Declaration of interests

The authors declare no conflicts of interest.

[1]Department of Cognitive Science, Johns Hopkins University, Baltimore, MD, USA
[2]Department of Biomedical Engineering, Johns Hopkins University, Baltimore, MD, USA

*Correspondence:
lisik@jhu.edu (L. Isik).

https://doi.org/10.1016/j.tics.2024.03.007

References

1. McMahon, E. and Isik, L. (2023) Seeing social interactions. *Trends Cogn. Sci.* 27, 1165–1179
2. Papeo, L. (2024) What is abstract about seeing social interactions? *Trends Cogn. Sci.* 28, 390–391
3. Pitcher, D. and Ungerleider, L.G. (2021) Evidence for a third visual pathway specialized for social perception. *Trends Cogn. Sci.* 25, 100–110
4. McMahon, E. *et al.* (2022) Hierarchical organization of social action features along the lateral visual pathway. *Curr. Biol.* 33, 5035–5047
5. Varrier, R.S. and Finn, E.S. (2022) Seeing social: a neural signature for conscious perception of social interactions. *J. Neurosci.* 42, 9211–9226
6. Isik, L. *et al.* (2022) Perceiving social interactions in the posterior superior temporal sulcus. *Proc. Natl. Acad. Sci. U. S. A.* 114, E9145–E9152
7. Landsiedel, J. *et al.* (2022) The role of motion in the neural representation of social interactions in the posterior temporal cortex. *NeuroImage* 262, 119533
8. Walbrin, J. and Koldewyn, K. (2019) Dyadic interaction processing in the posterior temporal cortex. *NeuroImage* 198, 296–302
9. Masson, H.L. and Isik, L. (2021) Functional selectivity for social interaction perception in the human superior temporal sulcus during natural viewing. *NeuroImage* 245, 118741
10. Malik, M. and Isik, L. (2023) Relational visual representations underlie human social interaction recognition. *Nat. Commun.* 14, 7317
11. Haxby, J.V. *et al.* (2020) Naturalistic stimuli reveal a dominant role for agentic action in visual representation. *NeuroImage* 216, 116561
12. Wu, J. *et al.* (2024) Dual routes of chunking social interaction: insights from grouping two agent actions in working memory. *J. Exp. Psychol.*, Published online January 22, 2024. https://doi.org/10.1037/xge0001539