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Spotlight

How Does the Brain Infer Hidden Social Structures?

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Many everyday thoughts and actions are shaped not only by our direct relationships with others, but also by our knowledge of relations between third-parties. Lau *et al.* recently demonstrated how knowledge of one type of social relation – interpersonal similarity – shapes cognition and behavior, and shed light on the neural basis of such phenomena.

Imagine that you are at a party where you meet two people – Alice and Bob. You begin to discuss political issues and learn that you agree with each of your new acquaintances on about half of the topics that come up. You also encounter another person – Carlos – who usually agrees with Bob. How does having met Carlos shape how you think about Bob? As it turns out, your view of Bob, as well as Bob's future influence on you, depends not only on how often you agree with Bob, but also on how often you agree with Carlos, and how often Carlos agrees with Bob.

Lau *et al.* [1] recreated this situation in an fMRI study. In each block, participants indicated their opinions on a variety of issues, and then learned about the opinions of three other people, for example Alice, Bob, and Carlos. At the end of each block, participants were asked to guess what their own stance would be on an unknown 'mystery issue' based only on where Alice and Bob apparently stood on that issue. If participants only tracked each agent's similarity to themselves, their behavior and brain activity should only reflect how often each agent agreed with them. However, participants were exceptionally likely to assume that they would agree with Bob if Carlos, who usually agreed with Bob, also tended to agree with the participant earlier in the testing block.

Why might this happen? If Carlos usually agrees with you, this shapes your mental representation of Bob, such that you, Bob, and Carlos belong to the same inferred latent social group (Figure 1A), rendering Bob's opinions particularly influential on your own. However, if Carlos agrees with you on very little, Bob and Carlos become an out-group in the inferred latent social structure (Figure 1B). Thus, third-party relations shape who is included in one's ingroup in the inferred structure of the social world.

Different brain regions tracked different aspects of participants' relations to others. A portion of medial prefrontal cortex (MPFC) – the pregenual anterior cingulate cortex (pgACC) – tracked how often an agent agreed with the participant (Figure 1C). The pgACC also tracked a second-order similarity with the participant – specifically, the similarity between the participant's pattern of agreements with all agents and each agent's pattern of agreements with all agents (including the participant) (Figure 1D). Thus, the anterior and ventral MPFC, which has consistently been implicated in self-related processing [2], tracks not only direct similarities to oneself, but also others' similarities to oneself in terms of their relations to other people.

Similarly, a third model also took relations between third parties into account. This model (Figure 1E) assumed that participants would assign people to latent social groups based on observed choices (Figure 1A,B), consistent with behavioral data [3,4]. The right anterior insula (rAI) and inferior frontal gyrus (IFG) tracked the probability that each agent belonged to the same inferred group as the participant. Furthermore, activity in this cluster improved model predictions of participants' choices of whose stance to adopt on 'mystery issue' trials. Thus, responses in the rAI/IFG reflect inferred latent social structure and predict behavior.

In addition to advancing our understanding of how people learn ingroup/outgroup distinctions, this work is exciting when considered in tandem with the growing body of literature on how relations between third parties (and patterns thereof) shape cognition and behavior [5–7]. Whereas much past research in social neuroscience and psychology has focused on direct relations between oneself and others, recent work suggests that knowledge of relationships between others shapes a wide range of behaviors (e.g., gossip, who is used as a scapegoat, the efficacy of vicarious apologies) [5,6], that people often accurately track patterns of such relationships [5,8], and that the human brain retrieves such knowledge when encountering others, presumably to inform cognition and behavior [5,8–10].

Although Lau *et al.* focus on a different type of relations between people (i.e., similarities rather than friendships) than those studied in the aforementioned research, these phenomena are often related in the real world. Lau *et al.* demonstrate how at least one facet of knowledge of social relations shapes behavior through its influence on inferred latent social structure, and how this information is tracked by the brain. Future work could elucidate if common neural mechanisms support the integration of knowledge of other types of third-party relations (e.g., friendships, rivalries, social status) into representations of latent social group structure, and how such phenomena shape behavior.

This work also opens up many additional questions. For example, how might context

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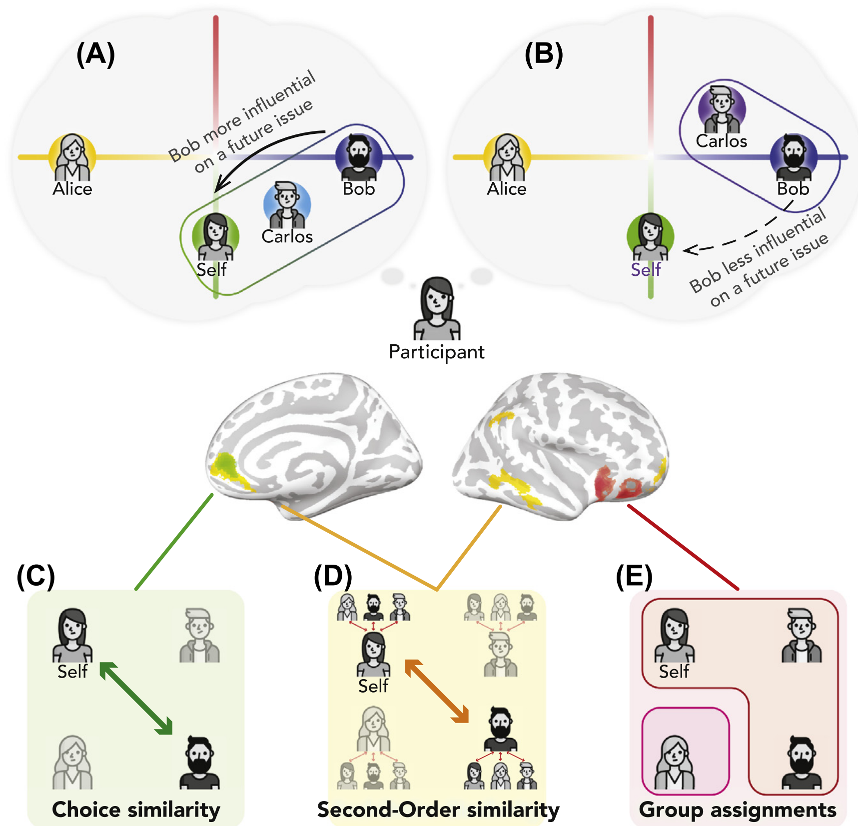

Trends in Cognitive Sciences

Figure 1. Inferring Latent Social Structure: Neural Mechanisms and Behavioral Consequences. (A,B) Latent social structures. Distance and the distinctiveness of colors represent how frequently people disagreed with each other. The inclusion of a third-party (Carlos) leads participants to be more (A) or less (B) likely to assume they will agree with Bob, rather than with Alice, on future issues. This depends on the relations between Carlos and everyone else, and thus on the inferred latent social groups. The medial prefrontal cortex (MPFC) tracked the similarity of agents to the participant in terms of their choices (C) and in terms of their similarities to other agents (D). The right anterior insula (rAI) and inferior frontal gyrus (IFG) tracked how likely agents were to belong to the same inferred latent social group as the participant (E). Icons were generated by monkik (www.flaticon.com), and results were visualized on the cortical surface using PySurfer (http://pysurfer.github.io).

and individual differences influence social structure learning? In addition, these analyses examined where neural response magnitude scaled with similarity to oneself in a variety of ways. Given that social information is also carried in distributed neural patterns, would additional regions be implicated if multivoxel response patterns were also considered? Furthermore, although tracking similarity to oneself and ingroup membership are undoubtedly important, it is also often important to track relations between third parties for its own sake. Inferred latent social structures based on relations between others could inform estimates of loyalties, rivalries, and channels of communication between others, as well as predictions regarding the behavior of others. Thus, future work should continue to elucidate the mechanisms through which purely allocentric social relations are learned [11], how such knowledge shapes inferred latent social structures, and associated behavioral consequences. Finally, Lau *et al.* used a highly constrained paradigm, providing great experimental control. To what extent would the same neural mechanisms support learning latent social structures when relations between agents are learned in more naturalistic contexts, such as through having conversations or observing realistic displays of social behavior (e.g., videos)?

Tracking patterns of social relations and inferring the structure of the social world are important for many aspects of everyday thought and behavior. Nevertheless, we are only beginning to understand how the human brain supports these capacities. Lau *et al.* demonstrate how one type of social relation shapes the inferred structure of the social world, and thus shapes behavior. This approach provides a promising way forward for better understanding this important aspect of human social cognition.

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