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Study shows how computation can predict group conflict

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When conflict breaks out in social groups, individuals make strategic decisions about how to behave based on their understanding of alliances and feuds in the group.

But it's been challenging to quantify the underlying trends that dictate how individuals make predictions, given they may only have seen a small number of fights or have limited memory.

In a new study, scientists at the Wisconsin Institute for Discovery (WID) at the University of Wisconsin-Madison develop a computational approach to determine whether individuals behave predictably. With data from previous fights, the team looked at how much memory individuals in the group would need to make predictions themselves. The analysis proposes a novel estimate of "cognitive burden," or the minimal amount of information an organism needs to remember to make a prediction.

The research draws from a concept called "sparse coding," or the brain's tendency to use fewer visual details and a small number of neurons to stow an image or scene. Previous studies support the idea that neurons in the brain react to a few large details such as the lines, edges and orientations within images rather than many smaller details.

"So what you get is a model where you have to remember fewer things but you still get very high predictive power -- that's what we're interested in," says Bryan Daniels, a WID researcher who led the study. "What is the trade-off? What's the minimum amount of 'stuff' an individual has to remember to make good inferences about future events?"

To find out, Daniels -- along with WID co-authors Jessica Flack and David Krakauer -- drew comparisons from how brains and computers encode information. The results contribute to ongoing discussions about conflict in biological systems and how cognitive organisms understand their environments.

The study, published in the Aug. 13 edition of the Proceedings of the National Academy of Sciences, examined observed bouts of natural fighting in a group of 84 captive pigtailed macaques at the Yerkes National Primate Research Center. By recording individuals' involvement -- or lack thereof -- in fights, the group created models that mapped the likelihood any number of individuals would engage in conflict in hypothetical situations.

To confirm the predictive power of the models, the group plugged in other data from the monkey group that was not used to create the models. Then, researchers compared these simulations to what actually happened in the group. One model looked at conflict as combinations of pairs, while another represented fights as sparse combinations of clusters, which proved to be a better tool for predicting fights. From there, by removing information until predictions became worse, Daniels and colleagues calculated the amount of information each individual needed to remember to make the most informed decision whether to fight or flee.

"We know the monkeys are making predictions, but we don't know how good they are," says Daniels. "But given this data, we found that the most memory it would take to figure out the regularities is about 1,000 bits of information."

Sparse coding appears to be a strong candidate for explaining the mechanism at play in the monkey group, but the team points out that it is only one possible way to encode conflict.

Since the statistical modeling and computation frameworks can be applied to different natural datasets, the research has the potential to influence other fields of study, including behavioral science, cognition, computation, game theory and machine learning. Such models might also be useful in studying collective behaviors in other complex systems, ranging from neurons to bird flocks.

Future research will seek to find out how individuals' knowledge of alliances and feuds fine-tunes their own decisions and change the groups' collective pattern of conflict.

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