Social dynamics modulate conformity during patch foraging

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Abstract:

Cooperation enables humans and animals to achieve challenging goals together, such as teaming up during hunting to capture larger prey. These successes may have driven the evolution of conformity and social learning of group norms. One could conform only to the extent that the information benefits them, called informational conformity, or they could go beyond that out of desire to fit in the group, referred to as normative compliance. The extent of conformity may vary based on the activity, expertise, and reward structure. For instance, in evolutionarily relevant tasks like foraging, where individuals demonstrate optimal behavior, informational conformity may prevail, as individuals may prioritize what benefits them over fitting in with the group. However, whether this holds true is unclear and forms the basis for this study. While most of the lab-based foraging experiments focus on individual behavior, this study seeks to investigate how the presence of virtual agents impact patch foraging. While foraging solo resulted in near-optimal behavior, as predicted by the Marginal Value Theorem. However, when social cues came into play, individuals deviated from optimal decisions, demonstrating normative conformity. When the reward structure induced competition, normative foraging was reduced. We then developed a hierarchical Gaussian filter to understand the mechanisms underlying changes in normative conformity.

Keywords: foraging; social cognition; drift-diffusion model; hierarchical Gaussian filter; conformity

Introduction

To understand the mechanisms driving normative conformity, it is important that we understand the motivations driving group behaviors. Cooperative behaviors may have evolutionary roots, shaping conformity and social learning within groups (Asch, 1951). However, the extent to which individuals conform, whether for informational gain or social acceptance, still remains largely unknown.

To study group foraging we used a naturalistic patch foraging game. Even in virtual versions of the patch foraging game, participants have demonstrated near-optimal behaviors according to the Marginal Value Theorem (MVT) (Charnov, 1976). However, the impact of group dynamics on foraging remains unclear. Social information intake can alter individual patch stay decisions (Turrin et al., 2017), but if it could potentially lead to suboptimal outcomes for the group in a patch foraging paradigm is unclear. Lastly, factors such as task expertise and reward structure can also influence conformity (Greenberg et al., 2021). In this study we also investigate how a change in reward structure and group dynamics affect foraging behavior.

Methods

In this study, 96 young adults played a multiplayer game based on solo patch foraging experiments. The paradigm was inspired by solo patch foraging experiments, where individuals collect rewards from resource-rich "patches" (Yonce et al. 2021) but adapted to accommodate group foraging. Participants interacted with virtual agents and were assigned to diamond patches. Clicking a patch five times harvested diamonds with diminishing returns. They could move to a new patch by clicking a trigger button ten times, with a total energy reservoir of 750 clicks. The round ended when energy ran out, and compensation was based on total diamonds harvested, requiring players to balance harvesting with leaving patches unharvested.

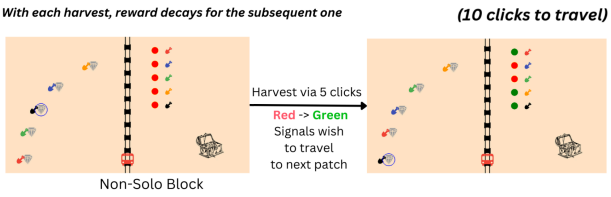

Figure 1: Task Design. Solo block does not have cues from other agents

One experimental manipulation involved solo and group foraging blocks, with virtual agents either over-harvesting or under-harvesting or optimally harvesting in the group block. Experiment 2 expanded the design with competitive and shared reward blocks, exploring varying reward structures and social interactions. In the shared rewards block, rewards were equally distributed among participants (results not shown here), while in the competitive block,

rewards were asymmetrically distributed based on individual rankings.

Results

Participants foraged optimally in the solo block of the paradigm. That is, the patch stay duration of the subjects in the solo block did not significantly deviate ($p>0.05$) from the optimal stay duration as per the Marginal Value Theorem (MVT). We then sprinkled in some social dynamics: interestingly, in the group foraging block, when the virtual agents over-harvested, the participants over-harvested (Mean deviation from the optimal =3.95 and $p<0.05$); when agents under-harvested, participants also under-harvested (Mean deviation from the optimal=0.47 and $p<0.05$); when agents were optimal, the participants were also optimal. Overall, from the group foraging blocks, we observed unequivocal evidence for normative conformity in patch foraging. Lastly, in the competitive block when the participant competed with the agents for reward, conformity reduced, making individuals more optimal again.

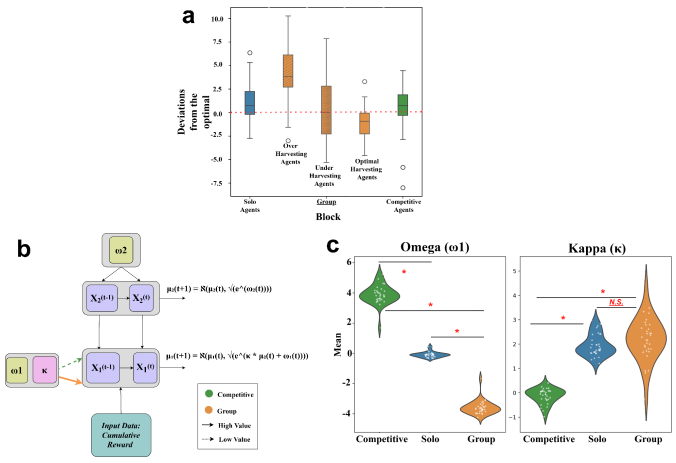

Figure 2: Results. a) Deviations from the optimal stay duration in solo, group and competitive blocks (error bars represent SD). b) 2-level hierarchical Gaussian filter c) High omega and low kappa characterized the gameplay in the competitive block.

Next, to understand the mechanism behind normative conformity and the subsequent competition-induced reduction in it, we used a hierarchical learning model. More specifically, we used a 2-level Hierarchical Gaussian Filter (HGF) to model the change in cumulative reward accumulation. Here the tonic volatility parameter ω conveys the irreducible uncertainty in the reward rate for the block. As expected, irreducible uncertainty is highest in the competitive block where the agents leave at different times. Irreducible uncertainty is lowest in the group block where they simply follow the virtual agents. Next, we examined Kappa (κ) parameter that represents coupling between the higher level (level 2) and the lower level. Here we found that κ was higher in the group block than in the competitive block. In the competitive block κ almost reduced to zero suggesting that the updates at the higher level, about the other agents' behavior that may be altering one's rewards were being tracked, those had almost no bearing on the lower level actions of the participant. Reduction in κ could be evidence for voluntary desynchronization to carry out one's task unhindered. When we modeled decisions using a drift diffusion model, we found that the drift rate was higher, and the boundaries were lower, indicative of greater motivation and urgency in the competitive block compared to the group or solo blocks.

Discussion

This study explored how group dynamics, and social cues affect decision-making in patch foraging. Virtual agents' actions notably influenced normative conformity, while reward structure reduced it. In particular, competitive environments with uneven payoffs led individuals to downregulate normative conformity, resulting in more optimal decision-making.The HGF model shed light on the dynamics of belief updating: while omega reflected the increase in irreducible uncertainty in the competitive block, reduction in kappa mitigated the impact of the behavior of the virtual agents on the participant. By combining a novel group patch foraging task with a cognitive computational model, we were able to shed some light on the mechanisms underlying normative conformity and its reduction thereof due to increased competition.

Acknowledgments

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