Commitment and Participation in Public Goods Games (JAAMAS Extended Abstract)

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1. INTRODUCTION

Before engaging in a group venture agents may seek to secure commitments from other members of the group, and based on the level of participation (i.e. how many group members commit) they can then decide whether it is worthwhile joining the group effort [12, 1, 5]. Many group ventures can be launched only when the majority of the participants commit to contribute to a common good [3]. While some international agreements require ratification by all parties before entering into force, most (especially global treaties) require a minimum less than the total number of negotiating countries [1, 3]. In group or coalition formation in multi-agent systems, a sufficient number of participants needs to agree on the terms of the agreement for it to be binding [13]. Commitments have been widely studied in multi-agent and autonomous agent systems, in order to ensure high levels of cooperation among agents [21, 2, 20]. They have also been utilized for ensuring good behaviors in various computerised applications such as electric vehicle charging [19] and peer-to-peer sharing networks [14]. In general, it appears that the required participation level depends on the nature of the problem in place.

We investigate analytically and numerically whether commitment strategies, in which players propose, initiate and honor a commitment deal, evolve as viable strategies for the evolution of cooperative behavior in the Public Goods Game (PGG), while at the same time analyzing the effect of the participation level and the transition from a single to multiple-rounds version of the game [6].

2. MODELS AND METHODS

2.1 Public Goods Game (PGG)

The PGG can be described as follows: all players can decide whether or not to contribute an amount c to the public good [18, 5] where their accumulated contribution is multiplied by a constant factor $r > 1$ before being equally distributed among all players. With r smaller than the group size (denoted by N), non-contributing free-riders gain more than contributors. Evolutionary Game Theory models [18] predict the demise of cooperation – famously known as 'the tragedy of the commons' [10].

2.2 PGG with varying participation level

In the commitment extension to the PGG [6], agents have, before playing the PGG, the option to propose other members in the group to commit to contribute, where the proposers pay a personal cost ϵ, to make it credible. If a sufficient number of the members commit (participation level F), the PGG is played. Otherwise, the commitment proposers refuse to play. Those who committed but then do not contribute have to compensate others at a personal cost, δ.

We distinguish N different participation levels for the one-shot PGG, encoded in terms of commitment-proposing strategies, $COMP_F$ where $F \in \{1, ..., N\}$. $COMP_F$ contributes c to the public good when there are at least F players in the group (including herself) that agree or commit to contribute; otherwise, the strategy refuses to play. Examples for such a minimum membership requirement can be found in the creation of treaties that address international environmental issues [1, 3] or the formation of coalitions in multi-agent systems [16, 17].

These new strategies allow us to investigate how the severity of the game (defined by $r < N$, where lower r values correspond to a tougher PGG) and the parameters of the commitment system (ϵ and δ) influence the required participation level. Second, we examine how strict, in case the PGG is repeated for multiple rounds R, these $COMP_F$ players should be when they notice that among those that committed to contribute, some of them did not honor the deal: should they immediately claim the compensation or might it be worthwhile to be lenient and continue the game? In that case how lenient should an agent be? Again we determine here how the three parameters, r, ϵ and δ, affect the answers to these questions.

3. SOLUTIONS SUMMARY

We have provided in [6] a new evolutionary game theory model, which shows that arranging prior commitments in multiagent group interactions, not just pair-wise ones [7, 8, 9, 11, 4], provides a pathway towards the evolution of cooperation in the typical Public Goods Game (PGG). Moreover, this model solution provides novel commitment solution in

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group interactions when restriction measure may not always be possible as it is costly and takes additional effort to implement [5].

Our analytical and numerical results showed that if the cost of arranging commitment is sufficiently small compared to cost of cooperation, then commitment arranging behavior becomes frequent, leading henceforth to high levels of cooperation in a population sporting a representative variety of playing strategies. Furthermore, an optimal prior commitment participation level emerges, dependent both on the common goods dilemma and on the cost of arranging commitment. In particular, the harsher the dilemma and the costlier the commitment, the higher the required commitment participation level to ensure the success of the joint venture. Additionally, as a commitment deal may last for more than one round, we evince that longer-lasting commitments require a greater strictness upon fake committers than short ones.

The results we obtain are in close accordance with experimental economic outcomes obtained by others [3]. The work further reveals that, whenever the compensation that needs to be paid by fake committers reaches a certain threshold, increasing it does not lead to improvement in terms of cooperation levels. It implies that, when designing norms, whether in real life or a self-organizing MAS, it is not necessary to have an infinitely large compensation or sanction against law breakers, for a sufficient one is enough for a wide range of situations.

As commitments have been widely studied in AI and Computer Science, e.g. to ensure cooperation in self-organized and distributed (large) multi-agent systems [21, 7, 2, 20, 14], our results provided important insights into the design of such systems whenever dealing with group interactions. For instance, in finding the effective degrees of commitment one should require from group members which lead to highest levels of cooperation. The key to using the potential of self-organized multi-robot systems is that the robots need to ensure a high level of cooperation amongst themselves [15], as they may have different skill sets. Our group commitment approaches appear suitable to ensure cooperation herein: the robots can arrange commitments to ensure that a beneficial coalition of skills is obtained and the task is fairly distributed; non-committing ones are restricted from the group and a joint mission is not launched unless the number of committers is sufficiently high.

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