

Power and Negotiation: Lessons from Agent-Based Participatory Simulations

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ABSTRACT

Participatory simulations are conducted to improve our knowledge of human behaviors, to help in solving conflicts, to shape interaction protocols between humans and to teach some aspects of collective management.

Agent-based participatory simulations differ from other kinds of participatory simulations including role playing games and experimental economics simulations. The control architecture of the agents, in these simulations, is more or less integrally replaced by a human player and the interactions between players are limited by the communication protocols designed for the agents, usually the exchange of electronic messages logged for further analysis. Such systems can be considered as ideal multi-agent systems featuring cognitive and intelligent agents. Previous work demonstrated that running this kind of simulations helps to design and improve multi-agent simulations.

In this paper, we present a series of agent-based participatory experiments studying negotiation in an abstract case of common resource pool management. The roles were designed in such a way that conflicts should emerge during the negotiations. Observing the behavior of human players, we noticed the apparition of power relations between players. We observed that this power in negotiations was unrelated to any a priori dependence between agents or between roles but was instead drawn from strategies and, more surprisingly, this power was built on an emerging ontology.

General Terms

Experimentation, Design

Keywords

Agent-based simulations, Participatory simulations, Negotiations, Power relations

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1. INTRODUCTION

The increasing use of computer-aided participatory simulations is related to an increasing coupling of participatory experiments with agent technologies.

One tradition of participatory simulations consists in combining role playing games with multi-agent systems [4, 5] within what was called the MAS/RPG methodology. Mainly concerned with common resource pool management, researchers from this tradition primarily use participation to better understand human behaviors. This methodology can be interpreted as a kind of participatory design, with an iterative process alternating role playing games and multi-agent simulations, aiming at building systems closer to the actual social phenomena.

Experimental economics, the oldest tradition of participatory simulations, now includes hybrid experiments with agents taking part in the simulation in order to validate and improve models or train participants [18]. The growing use of software agents as human peers fostered methodological studies such as the work of economists Jens Grossklags and Carsten Schmidt on the actual impact of revealing the presence of software agents [13].

From a multi-agent point of view, we define agent-based participatory simulations as simulations where human players take the control of agents. Unlike role playing games or experimental economics, these simulations are built with a multi-agent simulation design methodology. The model is agent-based and the interactions between the entities of these simulations are limited to agent-like interactions. Replacing the control architecture by human players builds up an idealistic multi-agent system with cognitive and intelligent agents. Previous work, based on a coalition formation problem, showed that the strategies elaborated by human players can overtake the distributed solving capabilities of the original multi-agent system [16].

The rationale of SimCommod agent-based participatory experiments was to study possible power relations in negotiations between ideal cognitive agents. The notion of power studied here is limited to negotiations and is based on Dahl's definition [10] : getting an agent to do something that it wouldn't do otherwise. It is of course not what happens when an agent sends a message to or calls a method of another agent.

Such power relations, among other aspects of negotiations, are extremely difficult to model and implement in multi-agent systems. Fifteen years ago, Cristiano Castelfranchi pinpointed the lack of social power in various models of

multi-agent systems [9]. Building on Castelfranchi’s work, power in multi-agent systems has been historically associated with a dependence relation. Nevertheless, the tradition of participatory experiments shows that power is not limited to dependence.

This paper is organized as follows. We will first present the background of SimCommod participatory experiments including the notions of power and negotiations in both multi-agent systems and participatory simulations. We will then describe the experiments and how the model and the experimental protocol were tailored to analyze the ways to express power relations as agent interactions. Finally, we will present the results, with the strategies used to influence other players including the emergence of an ontology and we will compare them with power relations in participatory simulations not based on an agent methodology.

2. BACKGROUND

While any interaction between agents can be considered a negotiation, power attracts surprisingly very little interest in the agent community. Participatory simulations, by contrast, almost always feature roles with a priori power relations.

2.1 Negotiation and power in multi-agent systems

Negotiation can be defined as a discussion aimed at reaching an agreement. It can be translated in agents terminology as interactions between agents aimed at a cooperative behavior, ranging from concluding contracts to sharing beliefs. A working group at IWMA98 [19] tried to characterize negotiation between agents and concluded that negotiation is an extremely broad term that covers most agent interactions. Indeed, our agents usually interact specifically to cooperate or share information.

Historically, negotiation between agents followed fixed protocols and agents that negotiated were designed at the same time. The protocol can be as simple as voting, which is considered a negotiation in the agent literature. With the standardization of agent communication languages, research can now focus on negotiation in open environments with autonomous agents of different origin and design. The very first difficulty when agents engineered by different programmers for different tasks need to negotiate is to allow them to perform an ontology alignment, i.e. to agree on what they negotiate about [22].

While they do provide a framework for collective behaviors, these negotiation protocols have very little in common with real-world situations of conflict. Unlike people, agents are designed to cooperate. Negotiation protocols that lack the notion of power are obviously inadequate to describe real-world conflicts.

Cristiano Castelfranchi introduced the notion of power in multi-agent systems by drawing a social power theory [9]. An implementation of this theory was proposed, relying on dependence relations between agents and on the ability to reason about others [21]. Dependence relation theory was later improved to address the case of dependences between more than two agents and to be more robust to possible changes in the strategies of other agents [7].

However, in participatory simulations, some of the power relations within the negotiations are not dependence relations.

Type	Expected outcome	Participants	Examples
Research	Design, improve and validate models	Stakeholders	SHADOC, SimCafé, PAT
Education	Teach the articulation between individual and collective behaviors	Students	Virus, ButorStar
Action	Favor negotiation between stakeholders	Stakeholders (exchanged roles)	Sylvopast

Figure 1: Typology of participatory simulations

2.2 Negotiation and power in participatory simulations

Participatory simulations can be sorted into three different kinds based on their expected outcomes (Fig. 1). Research participatory simulations aim at designing, improving and validating models of social behaviors. Education participatory simulations focus on training students and teaching them the articulation between individual and collective behaviors. Action participatory simulations try to favor negotiation between stakeholders by exchanging their roles.

In Sylvopast [11], an example of action simulation, participants are foresters or shepherds. As defined by their role, shepherds cannot perform forest management. They need to find incentives to convince the foresters to adapt the forest to their sheep. Officially, the foresters are independent and can ignore the requests of the shepherds. Actually, if the shepherds are eliminated after going bankrupt, the computer model will set fire to the forest. While there have been occurrences of this scenario during some experiments, stakeholders playing Sylvopast often know each other and share an history of common work in the forest. In spite of tensions between the two groups, they often succeed to cooperate.

ButorStar [17] is a typical example of an education participatory simulation as it was specifically designed for teaching purposes. Roles represent different stakeholders of the reedbeds: hunters, fishermen, breeders, reed harvesters and environmentalists. These roles are designed with conflicting interests and particularly, the economic interest of the other players is conflicting with the environmentalists who try to preserve the great bittern, an endangered species living in the reedbeds and after which the game is named (*Butor Etoilé*). In this role playing game, players have to cooperate to choose an irrigation level that affects everyone’s outcome. The game master enters the final decision in the computer and, when no agreement emerged, the actual irrigation is the worst possible case for everyone.

In these examples, negotiation is a key element of the experiments. The models even punish negotiators who have failed to reach an agreement. The negotiation phase takes place in natural language, without the help of any computer. Many factors influence the outcome of the negotiation and are not logged or related to the game. We have no scientific means to analyze the power relation between players during such games. In fact, role playing game designers often intro-

duce a priori power relation between the roles they define. Interestingly, they notice the number of players with a given role affects the outcomes of the negotiation. For example, in ButorStar, two environmentalists rather than one will better succeed in preserving the great bittern because they are more convincing.

On the contrary, most experiments in economics, which are of the research type, do not channel negotiations through natural language. Instead, interactions and negotiations are based on abstract symbols for two reasons. First, the price, which is what is most often negotiated, is decided by using what economists call institutions, i.e. the mode of interactions between agents. Institutions usually consist in some auction protocol. Second, experimental economists use abstract symbols instead of representation of emotional concepts such as endangered species and players are anonymous to avoid conflicts with a previous relation [12, 8]. Economist James Andreoni argued that players behave differently depending on how things are called [1].

3. THE SIMCOMMODO EXPERIMENTS

The SimCommod experiments are agent-based participatory simulations that used the Simulación framework [15]. They inherit the conflicting situation of the e-ComMod model and they also borrow methodological aspects from experimental economics. The experiments took place in june 2005 in the Laboratoire d'Informatique de Paris VI and in september 2005 in the National Institute of Informatics, Tokyo.

3.1 Agent-based participatory simulations

Agent-based participatory simulations are multi-agent simulations where human players act as the control architecture of agents. In experiments based on the Simulación framework, each agent is a network entity. Each player sits at a computer and interacts with other players through the computer only (Fig. 2).



Figure 2: A player in an agent-based participatory simulation

The design of agent-based participatory simulations follows standard multi-agent simulations design methodologies. In particular, the process is iterative and consists in transforming the domain model into an operation model. While the operational model of multi-agent simulations is the actual code, in agent-based participatory simulations it is threefold: the experiment protocol, what players can do (agent effectors) and what information they have access to (agent sensors). When testing interaction patterns, the most important step in this design process is to break the exchanges into smaller primitives so that players can have unexpected behaviors and are not forced to comply to the original domain model [14].

Interactions are limited to messages exchanged between agents and are therefore easily recorded with one or more log agents on the network. The logs are then used for further analysis of the interaction patterns. Moreover, the environment which is the subject of the negotiation is yet another network entity. In the SimCommod experiments, the environment was simulated by a multi-agent model in Cormas [6]. Cormas could also simulate some agents such as the government.

3.2 The e-ComMod model

The e-ComMod model has been designed to epitomize the companion modeling approach [3]. It derives from classical models of participatory simulations belonging to the common resource pool management modeling tradition.

The environment is simulated by a cellular automata implemented in Cormas. It is represented by a grid of 16 cells. A resource is distributed on the cells. The amount of resource on each cell is a discrete property with four different levels, from none to plenty, represented by shades of green (Fig. 3).

Agents in the model belong to three different classes: the harvesters, the environmentalists (also called the conservationists) and the government (the policy maker). The harvesters are the agents really acting on the environment. The government can only prevent them from acting on some cells and the environmentalist has strictly no direct influence on the environment.

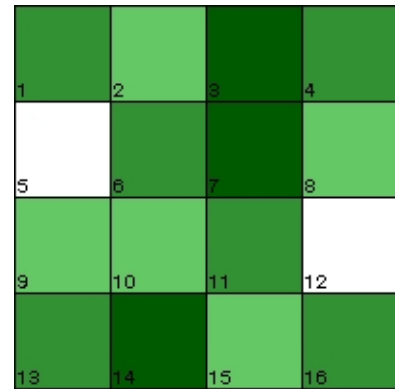


Figure 3: Environment: a grid with shades of green

The experiment is divided in turns. Each turn is divided in 4 phases: harvest, proposition, negotiation and validation.

- During the first phase, the harvesters can work on a maximum of three cells. The yield of a cell depends on the amount of resource and on the number of harvesters. The resource available on the cell is distributed to the harvesters.
- During the proposition phase, the harvesters and the environmentalists put positive and negative tokens on the map. The positive tokens represent the cells that they want to harvest next turn and the negative tokens represent the cells that they want to protect from being harvested. The harvesters have three tokens each, which they can cast as positive or negative tokens, and the environmentalists have ten tokens each.
- During the negotiation phase, the propositions are revealed synchronously to all players (Fig. 4). They can submit a new distribution of their tokens with an optional comment in natural language. The sum of the propositions may or may not converge during this phase.
- During the validation phase, the government decides to ban three cells. These three cells will not be available for harvesting during next turn. The decision can be taken from the sum of the tokens or the government can take actions to favor the emergence of a negotiation by penalizing the players who could not reach a consensus. The interface for the player who assumes the role of the government does not impose any strategy. The way the environmentalist and the harvesters affect this role's behavior is entirely up to the player. Besides, the user interface displays the discussion during the negotiation but the government cannot interfere with the negotiation process. It can only comment its decision.

The harvester's goal is to harvest as much resource as possible. There is competition among harvesters. Their best strategy is to harvest on cells with the maximum amount of resource and no other harvesters, since the resource is distributed among harvesters on a given cell.

Oppositely, the environmentalist's goal is to preserve the resource. The environmentalist does not act except by putting tokens on the map to influence the decision of the government. e-ComMod is similar to ButorStar in this respect where what some players could do was only to influence decisions of others. In the Sylvopast model, on the contrary, the shepherds can give money to the foresters and sheep actually clean the forest and decrease the risk of fire.

The actual evolution of the cellular automata is not revealed to the players, since they have to discover the dynamics of the game by themselves. The evolution rules of the level of resource on a cell do not depend on any other cell. In other words, the representation of the environment as a grid is strictly unrelated to the actual dynamics of the environment. The rules are the following:

- if more than one harvester is present, the level is decreased by the number of harvesters
- if one harvester is present, the level does not change.
- if no harvester is present for one turn, the level is incremented.

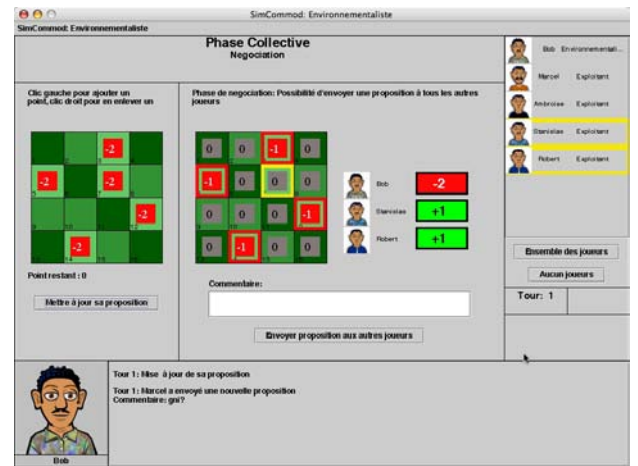


Figure 4: The user interface during negotiation

- if no harvester was present for the last two turns, the level does not change.
- if no harvester was present for more than two turns, the level is decremented.

These rules reflect actual common resource pool management situations where resource should not be over-harvested (more than one harvester) but a regular harvest maintains the resource.

3.3 Experiments to analyze power relations

A participatory experiment is typically conducted in three phases: a presentation of the model, the experiment and a debriefing session. The experiment conducted in the Laboratoire d'Informatique de Paris VI consisted in a single run. The model was calibrated during this first experiment. With five harvesters and one environmentalist, in addition to the competition between harvesters, the model featured a conflict situation: the environmentalist's goal is to preserve the resource and the pressure from the harvesters will make the amount of the resource decrease.

The experiments conducted at the National Institute of Informatics consisted of three runs. The first two sessions were performed in parallel and the government was played by an agent in Cormas. The players were told that the government would sanction the lack of agreement while in fact it played randomly. No complete agreement emerged, yet a player insisted that he found out that the government was acting randomly. During the third experiment, the government was controlled by a human player who penalized harvesters for their lack of agreement.

In order to study power relations between agents, the experiments had to be disconnected from the players' history. The participants knew each other, but the game was entirely anonymous. Players were represented by an avatar that was randomly chosen by the organizers (Fig. 4). While the simulation took place in an open space, players did not look into their neighbor's cubicle and seemingly did not try to find out who was controlling a particular avatar. Besides, when two experiments were conducted in parallel, players could not determine if their neighbor took part in the same

game. Anonymity seems to have been effective, even if negotiations were done in natural language: a player mistakenly thought that one of the avatar was driven by a particular fellow student while it wasn't.

An additional aspect of the methodology of experimental economics was introduced. Except for the name of the roles, the model used abstract symbols rather than emotional concepts such as an endangered species. The resource was only ever called "a resource" during the presentation of the model.

4. RESULTS

The analysis of the results is based on the logs of all exchanges during the experiment as well as interviews during the debriefing sessions. The most surprising aspect of the experiment is the emergence of a new ontology and its role in the power relations. This contrasts with previous participatory experiments grounded in real-world situations.

4.1 Ontologies and power relations

Although all participants had the same information about the game, during the first two runs conducted in parallel at the NII, one of the two environmentalists obviously negotiated better than the other. When asked about their strategy, both mentioned that they tried to preserve some specific areas that needed to be preserved. Their choice seemed to consist in preserving the lighter green squares.

The less efficient environmentalist explained that he tried to convince the harvesters to work on the cells that would provide them with the highest revenue while preserving the selected cells. In other words, it consisted in a rationale negotiation approach, trying to obtain a reasonable agreement that served everyone's interest. The player who chose to always follow the environmentalist's advice is the one who collected the highest amount of resource. Others mentioned they simply ignored his messages.

The more efficient environmentalist's strategy was instead to tell players not to harvest the specific cells she wanted to preserve:

I tried to protect this area by telling people "that's a very important area, go away", some people believed it very easily but some people opposed it.

The resource was better preserved with this strategy. According to these debriefing interviews, forbidding some cells proved to be more efficient than prescribing. Besides, this example seems to contradict common sense. Finding the agreement that satisfies one's constraints while maximizing other players' interest seems less effective than just trying to achieve one's goal and letting other players decide by themselves. This would contradict the social power theory as it would not be necessary to figure out the best interest of the other players.

In fact, the logs reveal that the main difference between the two environmentalists is not about forbidding and prescribing or advising. The more efficient environmentalist introduced notions such as endangered forest and trees, even if they were not present in the original presentation of the model that carefully used only abstract symbols. Furthermore, during the third experiment, the same environmentalist succeeded in prescribing as harvesters concentrated on some cells, allowing others to regenerate:

In the final turn, it was in a way good that many harvesters concentrate on one white cell and I saw many white cells empty, in the end it worked well.

The success of this new strategy, based on prescription like the strategy of the environmentalist during the first run, is again related to the introduction of concrete notions. The environmentalist told harvesters that they could find gold in these cells. She was conscious that harvesting white cells was their less efficient behavior and somewhat surprised that this argument worked so well. Reluctantly, some players admitted they believed her during the debriefing session and the logs show that some white cells were harvested indeed, decreasing the global pressure on the resource.

4.2 Comparison with participatory experiments

Participatory simulations based on real common resource pool management problems introduce an a priori ontology. They also use abstract symbols. In Sylvopast, for example, the vegetation type is represented by primary colors. The cells with forest are blue, with shrubs red and with grass yellow. This code allows combination with composed colors. Michel Etienne notes that after one round, players argue about "more yellow" or "more blue" instead of "more grass" or "more forest".

Such a use of abstract symbols is not contradictory with the results of the SimCommod experiments. Players in role playing games need an a priori ontology to negotiate but their discussion can be based on symbolic information. In fact, in newer flavors of Sylvopast, some new roles have their own ontology that they can use to influence other players. In particular, the objective of the newly introduced environmentalist is to preserve an endangered species of turtle living in the forest. The very idea of an endangered species of turtles is absent from the ontologies used in negotiations between foresters and shepherds.

The environmentalists in the SimCommod experiments may have used an ontology to convince and influence the players but nevertheless used the abstract symbols to clearly explain what they wanted. For example, the environmentalist during the third run at the NII told players to go on "white cells" because there was gold there. The action is expressed in the common ontology based on abstract symbols.

On the other hand, experiments in economics that do not allow the emergence of an ontology and that only include emotionless abstract concepts could more difficultly feature power relations. We previously ran an agent-based participatory set of experiments based on a cooperative version of the El Farol bar problem [2]. The concepts were all abstract, participants played anonymously. Lacking the possibility to communicate in natural language and therefore to create an ontology, they could not negotiate and did not exhibit any power relation. During the debriefing sessions, some participants insisted that they needed to be able to tag other players as liars or cooperative in order to negotiate.

5. CONCLUSION

In multi-agent systems, power is the corollary of autonomy and pro-activity. Cooperation between agents that do not have a slave behavior implies that agents must influence each

other, especially when interests diverge. Likewise, in agent-based participatory simulations with built-in situations of conflict, human players who control the agents necessarily introduce power relations.

The power relations in multi-agent systems have been previously studied as dependence relations. From a first look at the SimCommod experiments where there was no direct dependence between agents, we could infer that prescribing is less effective than forbidding as a way to influence others. We could also infer that it is not necessarily a good strategy to try to find an agreement maximizing the interests of the other agents. The real lesson from SimCommod experiments is probably that some actions such as introducing new ontologies can be a surprisingly effective way to influence other participants. Consequently, in the multi-agent negotiation protocols that take the ontology alignment into account, the ontologies should not be merged beforehand but during the negotiation.

More generally, this paper also advocates the use of agent-based participatory simulations to test and validate features of interaction protocols. In the forthcoming months, we plan to run additional agent-based participatory experiments based on a similar model to test overhearing and over-sensing protocols against direct interactions [20].

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