A serious game based on a public goods experiment

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***Abstract*—It has been pointed that public goods games lack experimental research in topics such as the study of the interaction of groups versus the interaction of individuals and effects of social identity and decision framing. Furthermore, the number of computational frameworks proposed to date to deploy these type of experiments is reduced. In this context, we propose the INVITE computational framework to serve as a useful research tool. The motivation behind the proposed framework is therefore straightforward: to allow researchers to be able to configure without difficulty public goods experiments where they can test their hypothesis regarding the behaviour of individuals, simulate behaviour of automated artificial intelligence and study the interaction between virtual agents and real persons. The greatest advantage of the INVITE framework is that it provides a high level of flexibility in the configuration of game theoretical paradigms. It is possible to configure simple structures such as the 2-player prisoner's dilemma or stag hunt as well as some of the most complex forms of inter-group conflicts such as team games. Accordingly, this framework allows an effortless parametrization, assisted by a tailored configuration tool, of a myriad of public goods games. Moreover, the 3D video game configured in the framework places the players in an immersive and engaging virtual environment where real-life conditions can be replicated and some circumstances, difficult to reproduce in real-life, such as life-threatening situations, can also be simulated. Given its characteristics, the proposed framework aims to represent an important contribution to the study of behaviour of both virtual and human players in scenarios of social conflict.**

I. Introduction

There is a growing interest in the topic of public goods games [4], [11], [13], [21], [26], [39], [41] and in particular in investigating experimentally subjects such as the study of the interaction of groups versus the interaction of individuals, the effects of social identity and gender, decision framing and payoff structure. Nevertheless and despite the added value that a computational framework on these type of experiments would have, the number of proposed frameworks is reduced. In fact, the most well-known computational frameworks of strategic games is the Colored Trails (CT) framework [17] and the z-Tree toolbox [14]. Notwithstanding the contributions of the frameworks, the usability of the CT framework could be improved since games have to be configured by coding in the platform and the z-Tree toolbox is not extremely flexible. To address these shortcomings, we propose a new computational framework – the INVITE framework, which allows configuring in a straightforward manner engaging scenarios of public goods games. The motivation behind the INVITE (social Identity and partNership in VIrTual Environments) framework is therefore to allow researchers to be able to configure without difficulty experiments where they can test their hypothesis regarding the behaviour of individuals as well as of artificial intelligence agents and study the interaction between the virtual agents and real persons.

The INVITE framework will allow the investigation of how factors such as social identity, discontinuity effect, group size and decision framing can influence the behaviour of individuals in different scenarios. Furthermore, the INVITE framework will provide, among others, the possibility to further analyse and study the establishment of partnerships between real and virtual players.

The INVITE research tool was developed as a computational framework allowing the configuration and deployment of public goods experiments in the form of a multiplayer 3D video game built over a distributed architecture. The game is set on a desert island after a plane crash. A volcano's eruption is eminent and the players only chance of survival is to built a raft to escape the island's destruction. Dilemma arises as greed can lead players to prefer to act solely on their personal interest and collect a private resource (such as gold) instead of contributing in favour of the group's common goal.

The framework allows the configuration of a myriad of game theory paradigms, ranging from the classical prisoner's dilemma, stag hunt, and chicken game to complex team games, that is, games in which conflict can be present at both the in-group and out-group level [4], in a common scenario of a video game. The ability to configure a wide range of game theoretical paradigms is an important property of the INVITE framework distinguishing it from other frameworks, such as z-Tree [14]. Furthermore, all paradigms are set in a common scenario with an appealing and involving fiction, in detriment of a more mathematical, abstract fiction (as in the case of the CT framework [17]). The fiction was designed in this manner to prevent the player from becoming detached.

The INVITE framework intends to introduce additional flexibility in the seemingly configuration of engaging scenarios of public goods experiments. Even though the framework places the player in a fictional scenario, we assume that the essential features of a real life setting of a public goods game are preserved and therefore we expect that in investigating these scenarios we are improving the understanding of real world situations of social conflict. Moreover, by creating fictional scenarios we have the convenience that we can place individuals in situations which might be difficult to simulate in real life such as life-threatening situations.

In conclusion, the major advantages of the INVITE framework is the flexibility of the framework provided by the seemingly configuration of a variety of game theoretical paradigms from the simplest game structures such as the 2-player one-shot prisoner's dilemma to complex intergroup conflict games (team games) and the engaging 3D video game environment.

II. Background

Situations of conflict of interests, such as the prisoner's dilemma, have been subject of debate since the publication of Leviathan by Thomas Hobbes (1651) [19]. Nevertheless, the formal creation of the field of social dilemmas can be attributed to Dawes (1980) [13] with his initial proposed definition of social dilemma as a social setting characterized by the fact that "the social payoff to each individual for defecting behaviour is higher than the payoff for cooperative behaviour, regardless of what the other society members do, yet all individuals in the society receive a lower payoff if all defect than if all cooperate". This definition has been revised by authors such as Liebrand (1983) [24] who proposed that a social dilemma is a situation in which individual rationality can be at conflict with social rationality. This revision has led games such as chicken and stag hunt[1] to be included in the category of social dilemmas, in addition to the classical paradigm of the prisoner's dilemma.

Fig. 1. Top view of the island, the setting of the INVITE framework.

Regardless of the precise definition of social dilemma, it is commonly accepted that public goods games can present social dilemmas to the individuals involved. A public goods game is a social setting in which each individual must decide whether to contribute to a common resource, designated as the public good, which is then subject to a scale factor and distributed among the members of the group or society [8]. If a public goods game is designed as a social dilemma, the rational behaviour of the individual is to not contribute, that is, to attempt to free-ride at the expenses of the contributions of others. Nevertheless, contradicting the predictions of rational choice theory, evidence from public goods experiments show that real persons often act "irrationally", that is, they tend to contribute to the common resource instead of free-riding [1]. This pattern of behaviour has raised questions on the reasons for this phenomenon and has led to a growing interest in this type of experiments [1], [9]–[12], [15], [16], [22], [26]. With the INVITE framework we aim to assist and promote research with this type of experiments.

[1]For a description of the chicken and stag hunt games refer to [31] and [38] respectively.

III. INVITE Framework

The scenario of the game was inspired by the work of Rapoport (1999) [29] and can be described briefly as follows:

> The game is set on a lost island where the player, along with the other players, is the survivor of a plane crash. Communication with the outside world is broken and players soon realise that they must leave the island in a number of days before the eminent eruption of the island's volcano. Their only chance of leaving the island alive is to build a raft.
> Players are assigned into teams, each team having the goal of building a raft. In order to help build his team's raft, each player can dedicate part of his day gathering wood. Instead of collecting wood, the player can spend part of his time gathering a private resource such as gold, valuable sea shells or coral (see Figure 4).
> If a team is able to build the raft before the end of the game, the members of the team are able to escape the island and the raft is sold. The earnings obtained from the raft are then distributed among the members of the team.
> The game is won by the player with the most earnings (either derived from individual collection or team's raft). Depending on the game configuration, members of teams which do not finish their rafts on time may lose all their earnings. Hence, during the game, players face the dilemma of either to contribute to the common good of the team (raft construction) or to contribute solely to their more individualistic goal (collection of the private resource).

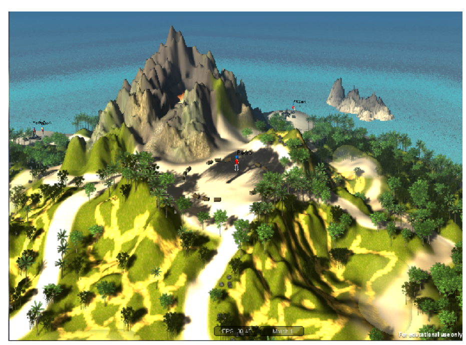

Fig. 2. In each day, each player decides either to collect a private resource (configured as gold, sea shells or coral) or to contribute to the team's common goal: the construction of a raft to leave the island before the volcano's eruption.

The following text details the list of parameters to configure a new experiment in the framework (see Figure 3).

Number of teams ($M \in \mathbb{N}$) defines the number of teams on the island.

Fig. 3. The INVITE framework includes a tool to easily configure a new experiment.

Number of players per team ($N \in \mathbb{N}$) defines the number of players in a team.

Number of days until end of game ($T \in \mathbb{N}$, $T \geq 1$) defines the number of days (turns) until the eruption of the volcano of the island. The volcano's eruption determines the end of the game.

Number of actions of player per day ($n \in \mathbb{N}$, $n \geq 1$) defines the number of actions each player has per day to spend collecting the private resource or wood. In each day (t), player i of team k decides the number of actions he intends to spend gathering wood ($s_{kit} \in \{1, \ldots, n\}$) while the remaining actions ($n - s_{kit}$) are spent collecting the private resource, hereafter referred as gold.

Earnings obtained from one unit of wood in the raft ($\gamma \in \mathbb{R}$) defines the earnings derived from one unit of wood from the raft. This parameter is used to calculate the earnings obtained by each team after selling the raft. Each unit of private resource derives one unit of earnings.

Necessary wood for raft completion ($B_{min} \in \mathbb{N}$) defines the necessary units of wood for the completion of the raft of each team.

Wood at start of game ($B_{ini} \in \mathbb{N}$) defines the already available units of wood of a team at the start of the game.

Maximum amount of wood in raft ($B_{max} \in \mathbb{N}$, $B_{max} \geq B_{min}$) defines if it is possible for a team's to continue to collect wood after the minimum amount of wood for the raft's completion has been reached.

Departure from island defines how the teams leave the island. It can assume the following values:

- At raft's completion: When this option is set the team always leaves the island when the team reaches the minimum wood for the raft's completion.
- At volcano's eruption: When this option is set the team can only leave the island at the end of the game.

Private resources accountability ($\lambda \in \{0, 1\}$) defines if the individual's private resource is accounted in his final outcome when the player does not leave the island.

Distribution rule of team earnings ($q_{ki}(N, s_k)$) defines how the earnings from the team's raft are distributed among the team's members. In this context, $s_k = \{s_{k1}, \ldots, s_{kN}\}$ defines the profile of contributions of team k with s_{ki} defining the contribution in wood of player i of team k accounted at the end of the game:

$$s_{ki} = \sum_{t=1}^{T} s_{kit}$$

The team earnings can be distributed according to one of the following modes:

- Egalitarian: The earnings are distributed evenly among the team members disregarding how much each player effectively contributed for the raft's completion.

$$q_{ki}(N, s_k) = \frac{1}{N} \tag{1}$$

- By contribution: The earnings are distributed according to individual effort in collecting wood.

$$q_{ki}(N, s_k) = \frac{s_{ki}}{\sum_{i=1}^{N} s_{ki}} \tag{2}$$

- Ultimatum distribution: The distribution of the earnings is decided by playing an altered version of the ultimatum game [40]. The player with the highest contribution proposes a distribution on the other players to vote. If the majority of the players accept the distribution the earnings are distributed accordingly otherwise all the earnings from the raft are lost due to lack of consensus.

Type of game defines the type of game played by the teams on the island. The outcome of a player (payoff function) and the outcome of a team (team's production function) is determined by the type of game.

The earnings obtained by team k depend on the team's production function $p_k(c)$. The production function of team k depends on the contribution profile of teams on the island (c). The contribution of teams is defined by $c = \{c_1, \ldots, c_M\}$ with c_k defining the wood collected by team k in the game:

$$c_k = \sum_{i=1}^{N} s_{ki} \tag{3}$$

The outcome of player i of team k ($u_{ki}(c, s_k)$) is calculated according to his earnings (s_{ki}) at the end of game and the earnings of the other players (c, s_k). Players can gain earnings directly by collecting private resources (each unit of private resources yields one unit of earnings) or indirectly by the final distribution of the earnings obtained from the sale of the team's raft.

There are the following types of games:

- Team neutral: In this type of game, the timing and effort of other teams do not interfere with the conversion of the wood of the team's raft. The payoff function is the following:

$$u_{ki}(c, s_k) = \begin{cases} (nT - s_{ki}) + \\ q_{ki}(N, s_k) p_k(c), \text{ if } c_k + B_{ini} \geq B_{min} \\ (nT - s_{ki})\lambda, \text{ otherwise} \end{cases} \tag{4}$$

  - Linear: In this game, players can continue to collect wood after the minimum amount of wood in raft (B_{min}) has been reached. The parameter B_{max} is set to ∞ and the production function is of the form:

$$p_k(c) = \gamma(c_k + B_{ini})$$

- Step-level: In this game, if the players of a team collect more wood than necessary this effort is not accounted in their final score since the boat can not accommodate more than the minimum required wood. The parameter B_{max} is set equal to the parameter B_{min} and the production function is of the form:

$$p_k(c) = \gamma B_{min}$$

- Team competitive: In this type of game, the timing and effort of other teams interfere with the conversion of the wood in the team's raft into earnings. The payoff function of team competitive games is the same of team neutral games (4). This type of games distinguish itself from neutral games by the fact that according to the order in which teams finish their rafts, or according to their effort at the end of the game, they are awarded with proportional prizes.
  - Linear: Linear competitive games are similar to linear neutral games with the distinction that additional prizes are awarded to teams according to their effort in collecting wood. Thus, the team with the highest collection of wood at the end of the game wins the largest prize.

$$p_k(c) = \gamma(c_k + B_{ini}) + prize_k$$

  - Step-level: Step-level competitive games are similar to step-level neutral games with the distinction that additional prizes are awarded to teams according to how quickly they finish their rafts. Thus, the team which finishes its raft first wins the first prize.

$$p_k(c) = \gamma B_{min} + prize_k$$

- Team cooperative: In this game, all teams in the island contribute to build a single raft which is used to escape the island. At the end of the game the wood in the raft is sold and the resulting earnings are distributed among all teams. In this game, the payoff function of a player can be of two forms:

  (1) Team-egalitarian: If the earnings obtained from the boat are distributed in an egalitarian manner:

$$u_{ki}(c, s_k) = \begin{cases} (nT - s_{ki}) + \\ \frac{q_{ki}(N,s_k)}{M} p(c), \text{if } \sum_{k=1}^{M} c_k + B_{ini} \geq B_{min} \\ (nT - s_{ki})\lambda, \text{ otherwise} \end{cases} \quad (5)$$

  (2) Team-by-contribution: If the earnings obtained from the boat are distributed according to the contribution of each team:

$$u_{ki}(c, s_k) = \begin{cases} (nT - s_{ki}) + \\ \frac{q_{ki}(N,s_k)c_k}{\sum_{k=1}^{M} c_k} p(c), \text{if } \sum_{k=1}^{M} c_k + B_{ini} \geq B_{min} \\ (nT - s_{ki})\lambda, \text{ otherwise} \end{cases}$$

  - Linear: In this game the raft built by all teams can encompass wood unlimitedly ($B_{max} = \infty$). The production function is of the form:

$$p(c) = \gamma(\sum_{k=1}^{M} c_k + B_{ini})$$

  - Step-level: In this game the raft built by all teams can only encompass the minimum required wood ($B_{max} = B_{min}$). The production function is of the form:

$$p(c) = \gamma B_{min}$$

List of prizes of teams ($\{prize_1, \ldots, prize_M\}$) defines the list of prizes to be awarded to the M teams on the island according to the order in which they finish their rafts or their effort in collecting wood (depending upon the configuration of type of game). This parameter should only be configured when the type of game is set to competitive mode.

IV. Use Cases

This section describes how some of the most well known strategic games such as the prisoner's dilemma or stag hunt can be modelled in the framework. Additionally it is explained how different team games can be modelled by changing the incentives to cooperation.

A. *Classical prisoner's dilemma*

The prisoner's dilemma is perhaps the most widely known paradigm of game theory [28]. The story reflects a situation in which individuals opting for "rational" decisions compromise their best interest. This structure can be recreated in the INVITE framework using the following configurations:

- Number of teams=1 There is one team of survivors on the island.
- Number of players per team=2 The team of survivors is composed of two players.
- Number of days until end of game=1 The game lasts only one day (one-shot game).
- Number of actions of player per day=1 The player can either collect wood to build the raft (cooperate) or collect a private resource in his own private interest (defect).
- Earnings obtained from 1 wood in the raft=$\boldsymbol{\gamma}$ A player in one action can derive one unit of wood and one unit of gold. Each unit of wood from the raft derives γ earnings to the team. Each unit of gold derives 1 earnings to the team. It should be noted that to guarantee that this is a prisoner's dilemma the following condition should be met: $1 < \gamma < 2$.

- Necessary wood for raft completion=$\boldsymbol{x}$ The raft requires a given amount of wood to be built.
- Wood at start of game=$\boldsymbol{x}$ At the start of the game there is already a portion of wood collected. This portion equals the minimum required wood to build the raft (B_{min}). Accordingly, it is always possible to leave the island.
- Maximum amount of wood in raft=$\boldsymbol{\infty}$There is no limit for the number of wood that the raft can accommodate.
- Departure from island=$\boldsymbol{End\ Of\ Game}$ At the end of the day players leave the island with the gold and wood retrieved during the day.
- Private resources accountability=$\boldsymbol{N.A.}$ This option is not relevant since players in this setting always leave the island.
- Distribution rule of team earnings=$\boldsymbol{Egalitarian}$ The earnings obtained from the raft are distributed evenly among the players regardless of their contributions.
- Type of game=$\boldsymbol{Team\ neutral\ linear}$ If a player cooperates he collects 1 unit of wood. If a player defects, he collects 1 unit of gold. Accordingly, if they both cooperate, the total collected wood (2 units) is translated into earnings (2γ) and divided evenly by the two players (γ for each). If they both defect each player leaves the island with their individually collected gold (1 unit). If one defects and another cooperates, the defector free-rides at the expense of the other gaining both his individually collected gold (1 unit) and also earnings from the raft ($\frac{\gamma}{2}$) while the other player only receives the "sucker's" payoff ($\frac{\gamma}{2}$). Accordingly the payoff matrix of this game is the following (with Table I presenting an example obtained after setting $n = 4$ and $\gamma = 1.5$):

	Cooperate (Wood)	Defect (Gold)
Cooperate (Wood)	γ, γ	$\frac{\gamma}{2}$,$1 + \frac{\gamma}{2}$
Defect (Gold)	$1 + \frac{\gamma}{2}$,$\frac{\gamma}{2}$	1,1

TABLE I. PAYOFF MATRIX OF PRISONER'S DILEMMA OBTAINED WHEN SETTING $n = 4$ AND $\gamma = 1.5$.

	Cooperate (Wood)	Defect (Gold)
Cooperate (Wood)	6, 6	3,7
Defect (Gold)	7, 3	4,4

B. One-shot multiplayer prisoner's dilemma

It is possible to configure the multiplayer prisoner's dilemma using the INVITE framework. The configurations required for the multiplayer prisoner's dilemma are similar to the ones of the one-shot 2-player prisoner's dilemma (refer to section IV-A) with the number of teams set to greater than 1 ($N > 1$). As in the case of the 2-player prisoner's dilemma, to ensure that the multiplayer game is a prisoner's dilemma one must guarantee that 1) when all players decide to collect wood to build the raft, the expected payoff of all players is higher than when they all decide to collect the private resource and 2) the expected payoff increase of preferring to collect the private resource over wood must be greater than zero [30]. These conditions are met in the multiplayer prisoner's dilemma when $\gamma > 1$ and $\frac{\gamma}{N} < 1$ respectively.

C. Chicken game

TABLE II. POSSIBLE PAYOFF MATRIX OF CHICKEN.

	Cooperate (Swerve)	Defect (Dare)
Cooperate (Swerve)	6, 6	3,7
Defect (Dare)	7, 3	0,0

The "chicken" metaphor can be traced back to Schelling (1963) [35] who used the allegory to discuss the problem of nuclear warfare. Table II presents a possible payoff matrix of the chicken game. The chicken game differs from the prisoner's dilemma in the fact that both the strategy of daring (defecting behaviour) and swerving (cooperating behaviour) are rational strategies. This follows from the fact that the payoff for the cooperator in the scenario of unilateral cooperation (3 in the example of Table II) is higher than the payoff in the scenario of collective defection (0 in the example of Table II).

The 2-player chicken game can be configured in the INVITE framework by creating a scenario, similar to the one of the prisoner's dilemma, in which the collective decision of defection (gathering the private resource) yields the worst possible scenario. To do so we followed the work of Santos et al. [34] who proposed a model to solve public good games by introducing the possibility of collective failure in the games' structure. In the authors' model the game was solved by imposing a minimum over the collective effort which the population had to reach to avoid the total loss of their endowments. In the same manner, to configure the 2-player chicken game the value of the minimum amount of wood in raft (B_{min}) should be set equal to the number of actions in the game ($B_{min} = n$) to guarantee that (1) in the setting of unilateral defection players are able to build the raft and that (2) in the setting of collective defection players are unable to build the raft and consequently do not leave the island alive yielding the worst possible scenario. Additionally, the parameter of private resources accountability (λ) should be set to zero ($\lambda = 0$) to ensure that if players do not leave the island they lose their private resources. The remaining parameters should be set in an identical manner to the prisoner's dilemma as detailed in section IV-A (including the restrictions of $\gamma > 0$ and $\frac{\gamma}{2} < 1$). Table III presents the general payoff matrix of the 2-player chicken game in the INVITE framework.

D. Stag hunt game

The stag hunt game is usually illustrated with a parable [38]. The story, transcribed below, was formerly included in Jean Rousseau's "Discourse on Inequality" [33] as a tale of social cooperation.

> "If a deer was to be taken, every one saw that, in order to succeed, he must abide faithfully by his

TABLE III. THE GENERAL PAYOFF MATRIX OF THE 2-PLAYER CHICKEN GAME ($B_{min} = n$, $B_{ini} = 0$, $\lambda = 0$, $B_{max} = \infty$).

	Cooperate (Wood)	Defect (Gold)
Cooperate (Wood)	γ, γ	$\frac{\gamma}{2}$,$1 + \frac{\gamma}{2}$
Defect (Gold)	$1 + \frac{\gamma}{2}$,$\frac{\gamma}{2}$	0,0

TABLE IV. THE GENERAL PAYOFF MATRIX OF THE STAG HUNT GAME ($2n \geq B_{min} > n$, $B_{min} = 0$, $\lambda = 1$, $B_{max} = \infty$).

	Cooperate (Wood)	Defect (Gold)
Cooperate (Wood)	γ, γ	0,1
Defect (Gold)	1,0	1,1

> post: but if a hare happened to come within the reach of any one of them, it is not to be doubted that he pursued it without scruple and, having seized his prey, cared very little, if by so doing caused his companions to miss theirs."

Stag hunt presents a pure coordination problem to the participants since synchronization of actions is necessary to achieve the collectively preferred equilibrium of the two possible ones: (1) players choose to hunt the stag and (2) players choose to hunt individually the hare. The dilemma resides in that by deciding to hunt the stag the individual can incur in both greater benefit and greater risk. The stag hunt game differs from the prisoner dilemma in the fact that the payoff of the defector in the scenario of unilateral cooperation is not the best possible payoff of the game with this being the payoff of the cooperator in the scenario of collective cooperation.

It is possible to configure the 2-player stag hunt game in the INVITE framework by creating a scenario in which the collective decision of cooperation (gathering wood) yields the best possible scenario. This can be achieved by (1) setting the minimum required wood (B_{min}) to a value that enforces that raft's construction is only guaranteed if all individuals cooperate (collect wood) ($2n \geq B_{min} > n$) and (2) by setting private resources accountability to 1 ($\lambda = 1$) so that the scenario of unilateral cooperation yields a better payoff to the defector than to the cooperator. The general payoff matrix of the game is depicted in Table IV. The remaining parameters should be set in an identical manner to the prisoner's dilemma as detailed in section IV-A (including the restriction of $\gamma > 1$).

V. CONCLUSION AND FUTURE WORK

Problems of public goods provision will continue to stem interest both in the experimental and theoretical fields and be prone to further investigation. Research will unfold into questioning why people behave in "irrational" ways and also how to promote cooperation. In this context, the INVITE framework aims to provide valuable insight into the complexity of social dilemmas and public goods games from its basic to its most elaborate shapes. We hereafter briefly review a list of interesting topics to study in the future with the INVITE framework.

a) Team games: Bornstein (2003) [4] defined a "team game" as a game in which both the elements of inner and outer group conflicts are present. In such games, players are assigned into groups, with each group facing an in-group social dilemma and an out-group strategic game. It is straightforward to configure this type of games in the INVITE framework by setting the number of teams (M) and the number of players per team (N) to values greater than 1. The interest of team games derives, from the most part, from the fact that a number of studies, such as the ones conducted in [18], [7] and [5] provide evidence that in these games, free-riding is reduced due to the embedding of social dilemmas in a structure of intergroup competition. In particular, Bornstein (1996) [7] reported that subjects were initially more likely (for the first fifteen rounds) to cooperate in the prisoner's dilemma if the game was embedded in a competition between two teams than in a single-group social dilemma. Accordingly, team game experiments can be studied to analyse how and in which specific conditions intergroup competition can promote cooperation.

It will be of special relevance to study how parameters such as the number of teams (M), number of players per team (N) and number of days until end of game (T) influence the cooperation rates of team games. A number of studies [2], [3], [8], [21], [25], [32] report that subjects tend to cooperate more in smaller groups than in larger groups. Hence, we can assume that by increasing the number of players per group incentives to defection increase. Bornstein (1994) [6] found that players tended to cooperate less over time in the prisoner's dilemma team game while in the general public goods team game tended to cooperate at about the same rate over time. Accordingly, we can also assume that by increasing the number of turns incentives to defection are increased.

b) Social identity: In the classic Robbers Cave experiment Sherif (1966) [37] demonstrated how common goals can foster the social identity of a group and how competitive activities can simultaneously increase hostility between members of rivals groups and increase the social identity within a group. Since experimental studies report that an increase in social identity leads to an increase in cooperation [8] it is expected that players cooperate more (collect more wood) in team games where social identity is more salient. Thus, it may be noteworthy to investigate in which type of games social identity is more salient and analyse the impact of that factor upon the cooperation rates of the games. As an initial hypothesis it is expected that individuals are more cooperative in team competitive games, where social identity is more salient due to the presence of external groups, than in team neutral games.

c) Discontinuity effect: The tendency of unitary groups to behave more competitively than individuals has been termed the discontinuity effect [20]. This effect has been demonstrated empirically [36] and contradicts rational choice theory which does not distinguishes between groups and individuals as decisions makers. As Bornstein (2003) [4] notes, further research could be conducted on this subject. This is consequently a relevant research matter.

d) Decision framing and visibility of parameters: It has been show that individuals react very differently in social dilemmas according to the description of the setting even if the incentive structure is objectively the same [8], [23]. These "framing effects" can be further investigated in the INVITE framework by changing for instance the introductory text of the game or the designation of the private resource. The INVITE framework can also be used to investigate how the visibility of certain parameters such as the number of days until end of game, gold and wood collected by each team member and total wood collected can affect the behaviour of the players.

We intend to continue to develop the INVITE framework to allow the configuration and inclusion of new parameters related with the characterization of the individual and team. We also

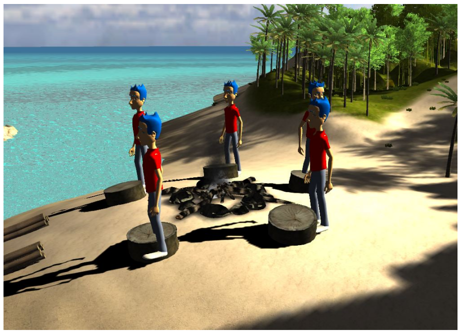

Fig. 4. Future work will focus on developing the players' characterization and group identity.

aim to research how to develop artificial intelligence agents which can interact with the human players of the INVITE framework as believable decision-makers. To accomplish this, rational choice as well as social identity theory and anticipation algorithms should play an important role in the development of the reasoning mechanisms of the agents [27]. Finally, the distinguishing characteristics of the INVITE framework will continue to be developed – its flexibility in terms of configuration and engaging and immersive 3D video game virtual environment.

VI. Acknowledgments

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