

# One for One and All For All: The Influence of Individual Goals in a Group of Agents with a Common Goal

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## ABSTRACT

There are several systems dealing with autonomous agents working as a group. In most of them, however, agents work for a common goal, not contemplating individual objectives. When two or more goals are available, many systems lack believability, for the choice is based mainly on utility. We aimed at creating a system which allows agents in a group to decide in a believable manner whether to follow an individual or a group's goal.

Our model is based on Psychology and Sociology theories, allowing our agents to decide what is more important, the group or themselves. This choice is based on agents' Egoism and on the attraction and influence they feel from the group. In turn, these depend on other factors such as personality, social relationships, outer stimulus, self-esteem or group's and agents' success.

We implemented our model on agents playing a semi-competitive game, Power Pentagram. On this game, agents must cooperate to win the different levels, at the same time they should compete in order to be in advantage against other members in the group.

The tests on our model showed that it successfully reflects different behaviors for groups with different constitutions, with results that would be expected for human groups.

## Keywords

Autonomous Agents, Egoism, Self-Esteem, Individual Goal, Group Goal, Believability, Individuality, Computer-Human Interaction.

## 1. INTRODUCTION

We are not alone! Humans belong to several groups: family, coworkers, club, and friends, among others. A social group [1] can be defined by two or more people who interact, and somehow identify with one another. As members of a group, and aware of it, we may see that we share experiences, loyalties, expectations, obligations, objectives or interests with other members. In a group, individuals see themselves as members of a "We", forming a special entity - the group - with special characteristics and several defining processes, differentiating it from other groups. But as members of groups, humans still keep their individuality, their personality, their own interests, their expectations and needs. We are not alone indeed. But "We" is also a set of "I's".

Autonomous agents [2] are not alone anymore either! Social agents [3] interact with other entities, such as other agents or humans. Some agents even interact as members of a group in several applications, mostly in the entertainment area (the games and cinema industries), but also in learning and training. However, it is common for agents in a group to act in a non-believable manner, decreasing the quality of the user's interaction with the system.

To increase believability [4] of such agents, much research has been made with the objective of modeling the group process in a satisfactory manner. However, what we can see is that when in a group, even if they have different personalities, agents tend to act in a very uniform way: they work towards the group objective, trying to increase the group's welfare. In fact, even when there are two types of objectives, the group's and the agents', agents choose based mainly on their gain, doing the rational thing, but lacking the existence of other factors such as personality and social relations' influence in that choice.

In order to model agents' behavior in a group, when they have to choose in a believable way between two goals: the individual and group's goal, we must therefore model the agents individually and the group's structure and processes. Beginning with the "I", we'll try to achieve a "We" where agents behave in a way that feels real, and not only rational. This is more important when a human user interacts as a member of a group of such agents. He must not think he is alone, as the only human among "stuff", but as a member of a group of individuals with different personalities, goals, and behaviors.

In this paper, we will briefly introduce works related with ours, which worked as a starting point for our model. Afterwards, we will introduce the Psychology and Sociology theories which justified the model's architecture. To describe our solution, we will also describe Prada's SGD Model [5], on which our model was built. Afterwards we will also introduce the changes we made on the original SGD Model, describing the system's architecture and some implementation details. To evaluate our model we had to create some autonomous tests. This document also describes such tests and its solutions. We will end by introducing our work's conclusions

## 2. RELATED WORK

When searching systems related to ours, we had a great difficulty: there are few works (if any) dealing with our problem, at least dealing with it the way we want. As a result, we felt the need to identify the main characteristics of the system, and search for works related with them individually.

The works studied in game and decision theory [6; 7] introduced a way to implement agents which decide with multiple options. When studying systems in this area, we notice that agents are rational, basing their behavior on the notion of utility. We believe utility is one important factor in our agent's goal choice, for it is logical to believe people tend to consider what's best for them when they have two options. However, we consider agents should take other factors into account, because while being members of a group, the relations in the group and the agents' personality are also factors of influence.

The area of emotional agents is strongly concerned in achieving believability through the use of emotions [8]. This justifies the

study in some works on this area, as they represent good approaches to create agents who don't simply act as flat, featureless characters. This believability is also achieved with non-predictable behavior, something that emotions also motivate [9].

Egoism and altruism are popular topics in agents interacting with other entities, whether individually or as members of a society. We studied the importance of this dichotomy in agents interacting with humans [10], in a society of agents emulating animals [11], and in a human-like society [12]. The egoism/altruism of agents will be an important factor in our agent's decision about doing what's best for them or for the group. However, unlike the introduced factors, we don't consider the agent's behavior should not only be driven from the egoistic level. For instance, an agent who is strongly identified with the group and an agent with no relations with other members should not act the same way, although having the same egoistic level.

Our agents work as members of a group. We introduced a Castelfranchi's work defining the several elements of social action for autonomous agents [13]. Tambe's STEAM [14], implementing some of Castelfranchi's ideas and designed to allow agent's teamwork, was also introduced, for it is one of the most successful systems, and a reference, in teamwork.

Castelfranchi's and Tambe's works don't contemplate any type of individuality in the agents in the team. We ended our related work by introducing several systems where agents have an individual choice on how to behave, while in a group. The way agents choose their actions was important to study, for in our system agents will also have two possible goals to choose, with several factors influencing this choice.

After studying related works, and not finding any dealing with the same problem our will deal, or at least not dealing with it the way we believe would be the better, we felt motivated to the development of our system. We believe it would be an important leap towards believable individual choice in an agents' team.

### 3. PSYCHOLOGICAL AND SOCIOLOGICAL BACKGROUND

#### 3.1 The Individual

Trait personality is nowadays the dominant paradigm in personality psychology. The Five Factor Model [15] is widely accepted as a taxonomy of personality traits. As the name indicates, the FFM represents personality using five traits: Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness. Neuroticism can be defined as the tendency for psychological distress, unrealistic ideas, and the tendency to feel negative emotional states. Extraversion is characterized by positive emotions, impulsivity, sociability and assertiveness. A person scoring high on openness to experience tends to present intellectual curiosity, be very imaginative, enjoy new experiences, be creative, liberal and prefer variety. Agreeableness is the tendency one has to be pleasant, trustful, compassionate and cooperative towards others in a social situation. Conscientiousness is related with impulse control. Conscientious people tend to be hard workers, well-organized, punctual, ambitious and persevering.

Derived from personality, there is a person egoistic/altruistic level. There are several definitions for egoism. One of such definitions is Rational Egoism [16], stating that it is always rational to follow own interest.

Also important to our work is the definition of self-esteem, which reflects the individual's sense of own worth, or how much a person likes himself. Self-esteem is derived from personality, being also related with several factors, like social class, gender, race, prestige, education, etc. M. Leary, G. MacDonald and J. Tangney [41] stated that individuals with higher Self-Esteem tend to resist to factors of influence, feeling free to be themselves.

#### 3.2 The Group

As said before, a social group [1] can be defined by two or more people who interact, and somehow identify with one another. As members of a group, and aware of it, individuals share experiences, loyalties, expectations, obligations, objectives or interests with other members. Members of a group have individual relations with other members, like being attracted or influenced by them. Such types of relations are also true for the group. Next, we will give a brief explanation on influence and attraction an agent feels for the group or other agents as entities.

- **Social Power:** Raven and French [18] defined social power as the influence exerted by a social agent on a person. This power is dependent on the power of the person being influenced and the person who is using the power.
- **Interpersonal Attraction:** Social Attraction [19] defines the relation between two individuals in terms of likes and dislikes. This defines the affective ties between individuals, and can be either positive or negative.
- **Group Influence:** When influenced by the group, a person tends to conform to it, compromising his/her own judgment to avoid being different, even from people they don't know [20].
- **Group Attraction:** the forces acting together to keep group members united, and engaged to the group [21]. The term encompasses such ideas as "group pride", "group solidarity", "group loyalty", "team spirit" and "teamwork".

### 4. SGD MODEL

As stated, our model was developed expanding and adapting Prada's SGD Model [5]. SGD Model was built to model autonomous agents' behavior in a small group, where they may interact with a human user to accomplish some task. The model aimed at achieving believable behavior, creating characters whose actions are based on psychological and sociological factors, and acting together to achieve a common goal. SGD Model, therefore, merges tools to model teamwork with a way to allow social interactions and psychological elements in the definition of agents.

This model already implements a knowledge base, holding the knowledge the agent has. Here, agents keep information about

the individuals in the group, the relations between them, the group itself, the possible goals at a given moment, and about the interactions that may occur.

This knowledge is used as an input for the agent's motivational system, other of SGD's features, originating updates, or being read when motivational system updates automatically in its update cycle.

When an agent is motivated to act, the following module – behavior generation - decides how to do it: in a rational manner, usually associated with instrumental actions in an attempt to reach a goal, or in a reactive manner, usually engaging in some sort of socio-emotional interaction.

Agents have the ability to “see” and classify the interactions occurring in the group. The identification of the interactions' category is the first module allowing the agents to deal with information coming from their sensors. This module also takes into account the context to define how the actions of the group should be interpreted (for example, by means of social norms).

After identifying the interactions, the effects are propagated in the knowledge base, updating the information it keeps. For example, the interaction may change the social relations established between the members that engage on it. Agents implementing SGD Model' behavior changes over time, according to what is happening in the world.

It also matters to state that SGD Model already implemented successfully the Five Factor Model's traits in the agents' mind. The agents' personality influences the agents' motivations, the social relations between them and the response to what happens in the group, among other factors.

## **5. A MODEL FOR THE CHOICE BETWEEN INDIVIDUAL AND GROUP GOALS**

The main differences in our model from the original SGD are more noticeable in the knowledge base and the agents' motivational system. However, other changes were made in order to allow the agents to solve the type of problem that our system deals with.

### **5.1 Knowledge Base**

The agent keeps the knowledge it possesses in the knowledge base. Separated in four levels – Individual Level, Social Level, Interactions Level and Context Level - according to the type of knowledge they hold. The knowledge base is one of the main components of our model.

#### *5.1.1 The Individual Level*

The individual level, similarly to previous versions of SGD, keeps information about the agent's individual characteristics.

In this level, the agent keeps information about its personality and abilities. The major difference relatively to the original SGD is the introduction of the notion of Egoism.

Based on D. Paulhus and O. John's work relating Egoism and the Five Factor Model [22], we consider that Egoism increases when

openness and extraversion increase, and decreases when agreeableness and consciousness increase.

The Egoism's value for an agent is calculated once, and kept immutable, for agents' personality is also (obviously) immutable.

#### *5.1.2 The Social Level*

This level keeps information about, or directly related with, social relations between the members in the group. The social level is separated in two sub-levels, related with knowledge regarding individuals' relationships and relationships between the individuals and the group as an entity.

##### *5.1.2.1 Social Level – Agents*

This level keeps information about social relations between agents in the group, namely Social Attraction and Social Influence. This sub-level brings a new factor to the model: the agent's Self-Esteem.

Following M. Leary, G. MacDonald and J. Tangney work [23], we consider that Self-Esteem can be related with the agent's “courage” to follow its individual goal. Agents with higher Self-Esteem trust more on their capabilities and resist more to influences than agents with lower Self-Esteem, less able to deviate from the behavior of the majority.

In our model, we will use Self-Esteem as a way for the agents to resist to different factors of influence, either originated in the group or from other agents. This way an agent with higher Self-Esteem will resist to outer factors, and act according to its personality. Agents with lower Self-Esteem will tend to yield to outside pressure, having their behavior influenced by others.

Self-esteem is derived from personality, as Gecas and Seff studied [24], in conjunction with the Agent's Success. In our model, agents have an individual objective, but are also members of a group with a common objective. This means that agents take into account their individual success, but also their success in the group to which they belong.

Agents' success is related with the agents' achievement and failure of individual goals. To calculate agents' success we need the ratio between successes/failures in the individual goal attempts. With an important weight in agents' success (and subsequently in self-esteem) is agents' personality. Agents with higher levels of extraversion give more importance to positive events (in this case, succeeding at a given objective), while agents with higher levels of neuroticism give more importance to negative events. Also with a weight in the agent's success' calculation is consciousness. This happens because agents with higher level of consciousness give more importance to task-related interactions.

Agent's success in the group is taken from agents' group position, a concept already existent in the original SGD.

##### *5.1.2.2 Social Level – Group*

This level introduces the relations of influence and attraction between the agent and the group. Similar to interpersonal attraction and influence, but now modeling these relations between the agent and the group, and not between two agents,

both concepts of Group's Attraction and Group's Influence were inexistent in the previous SGD. These two new concepts are important in the type of choice between two objectives our agents need to do, for an agent more attracted to or influenced by the group will act more on its behalf than a less attracted or influenced one.

Group's Influence defines the conformity of the agent towards the group, representing how difficult it is for an agent to deviate from the behavior of the group. In our system, this means that agents with higher conformity have more probability to work to the group's objective than to their personal objective. Group's influence is related with group's success, the cooperation level of other agents in the group, the current goal's difficulty and the agent's self-esteem.

The group's success is related with the group's achievement and failure of group goals, and calculated similarly to individual success, also taking into account the agent's personality.

The cooperation level is simply the ratio of other agents' actions for the group and total actions, working as an indicator of how committed they are to the group's goals. An agent will act more on the behalf of the group if it feels all members in the group will also act for the same objective.

Self-esteem works as a way for agents to resist to group's influence: the higher the self-esteem, the lower the group's influence.

The same way social attraction represents how attracted one agent is by other agent, our model also includes the notion of group attraction, representing the attraction an agent feels for the group. Following Cartwright and Zander's definition [21], together with the factors Festinger introduced as defining group cohesiveness [25], Group's Attraction is dependent on the attraction the agent feels for other members in the group and the group's success.

### 5.1.3 The Goal Level

The goal level defines the agent's goals, as well as the associated gain for the agent and the group, and the associated time, as follows:

- **Goal Definition:** describes the representation of the goal, according to the context.
- **Group Gain:** describes the gain for the group when the goal is achieved
- **Individual Gain:** describes the gain for the agent when the goal is achieved.
- **Time:** represents the time associated with the goal. A goal is only valid within a given interval, and should be achieved before that time extinguishes to get the corresponding gain.

Using to the gains for the group and the individual, it is possible for agents to differentiate the type of the existent goals. In our system, since we only want to model the choice between the individual and group goals, we decided to clearly distinguish these two types, with a goal being easily identifiable as "good for the group" or "good for an agent".

The individual goal, this way, has maximum utility for the agent, and the group goal has maximum utility for the group. According to the type of the goal, the agent has different motivations, which are calculated in a distinguishing way.

## 5.2 Motivational System

The agent's motivational system defines the agent's behavior. Like in the previous version of SGD, the agents' motivations are related with a Goal, have a Proactive ( $P_v$ ) and a Reactive ( $R_v$ ) components, an *Update* function and a *Threshold*.

The agent acts towards a goal when the sum of proactive and reactive components reaches the associated threshold, resetting their motivations' values to 0 afterwards. This way, the difference in the importance an agent gives to the individual or group's goal is reflected in how fast it reaches the threshold associated with each of those goals.

The pro-active motivation for the group's goal increases with time. The value of that increase is directly related with the values for group's attraction and influence, and inversely related with the value for Egoism. The value for the individual goal's motivation, oppositely to the motivation for group goal, increases with agents' egoism, and decreases with group's attraction and influence.

The values for reactive motivations for group and individual goals' increase are directly related to outer stimulus. The reactive motivation for pursuing the group's goal increases every time the agent sees other agent working for the group, or is encouraged by other agent. The reactive motivation for the individual goal increases every time the agent perceives that other agent is working for its individual group, or is discouraged by other.

## 6. IMPLEMENTATION

Our model was implemented in agents who play a game named Power Pentagram. Power Pentagram was born as a modification to Perfect Circle [5]. Our main goal in this change was to transform Perfect Circle in a semi-competitive game where five agents (all of them autonomous, or four autonomous and one human) travel a world of magic. Their mission is to find gems which, when combined, give them a predefined number of points. Gems can be found in different sizes, essences and purities. In that search, agents have a different set of abilities which allow them to change the gems according to their needs. Gems may also be used to give individual points to only one agent.

A game has ten levels. Each level has an associated group goal, a combination of three gems of varying size and purity. Each group goal grants different points, divided by all members of the group. Besides the points associated with a group's goal, there are individual goals, which when achieved, give the successful agent a given amount of points. To achieve an individual goal, an agent must achieve a certain amount of points in a level. In the end of the game, the agent with higher score wins.

Each level has an associated time. To get the group objective points, agents must also achieve them in the corresponding level's time. When the group fails to achieve the group goal, all its members' individual points gathered in that level are also

lost. This forces agents to cooperate with each other, no matter how egoistic they are.

Power Pentagon was designed to allow the testing of our model, including two types of goals (individual and group) with varying associated utilities, different types of interactions, and a success/failure level which allows all the psychological and sociological factors to change during the game.

The game was implemented using Java and Jess. Java was used to implement the game's loop and the classes responsible for having the two versions of the game (simulation and user game). There are Java classes representing the players, the group, the levels, the goals and the game itself. The player's actions (corresponding to the agents' effectors) are also implemented in Java. Jess, a rule engine written in Java, was used to implement the agent's mind. If Java implements and controls everything happening in the world, Jess gets inputs for the world, holds the agent's knowledge, and handles all the reasoning and outputs agents' actions. Jess, being a rule based system, is very competent in executing all the calculus needed to maintain an updated knowledge base, and generating the agents' behavior. Its easy integration with Java (since it was implemented in this language), allows keeping the game separated of the agents' mind.

## 7. EVALUATION

To evaluate our model, we ran several games with different groups' constitutions, using agents with different personalities. Some of the test group's personality were defined to assert different egoistic levels, while others were meant to control the influence of group's success and individual success's influence in our model. We also tested the influence of social attraction in group's attraction, to assert how different initial values for interpersonal relationships change our agents' behavior.

To test our system, we used Perfect Circle's Eval [7], a Java application that analyzes the log files from Perfect Circle (or in our case, Power Pentagon) and creates CSV files with the data organized in tables for easier interpretation.

The results of the tests allowed us to take some conclusions of our model's success in implementing agents who need to choose between group's and individual's goals, namely:

- An "all-egoists" group has worse results than any other type of group, for when all agents' care about themselves, the group's objective is never achieved.
- When in a mixed group, having some completely egoistic agents and some completely altruistic agents is also bad for the group's performance. This means that it is better to have a group where everyone cooperates (even if just a little) than a group where some cooperate totally, while others care just about themselves.
- The motivation for individual actions grew slower in groups where group's attraction and group's influence are stronger.
- Group's attraction has a real effect in the agent's behavior, for groups where the initial attraction

between agents is set to the maximum are more successful in terms of completed levels than groups where group's attraction is initialized as 0.

- When there is a single egoist in the group that agent is in clear advantage. Similarly, a single altruistic agent tends to lose the game, worrying simply with the group and nothing about himself.
- The existence of a highly altruistically agent in a group contributes for the success of the group, even when all other members are egoists. Such agents prejudice themselves but work as a dynamo for group's success.
- The existence of an egoistic agent in a group of altruists doesn't have a big effect on group's performance. However, one egoistic agent in a group of altruists clearly is in advantage, using other members' work to increase his success

## 8. CONCLUSIONS

The work presented in this dissertation intended to create a model to allow agents that, while acting in a group, have the ability to decide whether to work for the group or themselves. This decision is present in all semi-competitive games, but is usually centered on utility. When searching systems related with ours, we found several which used complex planning algorithms, notions of teamwork, emotions and personality, but none of them combining more than one factor. We wanted our model to allow agents to base their choice not only on utility, but mostly on Psychology and Sociology. This way, we wanted to achieve believable behavior, with agents emulating human behavior when in these types of situations, and clearly distinguishing the actions of different agents.

Our model was implemented extending and adapting Prada's SGD Model, which already implemented a knowledge base including the agents' personality, social relations and a motivational system allowing agents' decision. Our model's expansions were mainly centered in the agents' knowledge base and motivational module.

We introduced the goal level, clearly distinguishing between group and individual goals. We also introduced agent's egoism, working as a factor motivating agents to work for themselves, and group's attraction and influence, working as factors motivating agents to work to the group's goal.

The information existent on the knowledge base, together with outer stimulus from the world, defines the variations in the motivations for agents to follow the group or individual goals. The motivations can be of the reactive or pro-active types. Reactive motivation to individual goal increases when an agent X detects other agent Y is acting for himself, or if X gets discouraged by other agent Z. Reactive motivations for group goal occur when agent X detects other agent Y is acting for the group, or when is encouraged by Z. Agents' Egoism is directly related with the increase in the pro-active individual motivation and indirectly related with increases in the pro-active motivation for group goal. The group's influence and attraction are directly related with the increase in the motivations for group goals, and indirectly related with the motivation for the individual goals. An

agent acts on a goal when the sum of the corresponding motivations reaches a given value.

After implementing our model, and to test its success, we created several groups with different characteristics playing Power Pentagram. It is a semi-competitive game, adapted from Perfect Circle, where agents have to cooperate to complete the levels, and compete with others to win the game. Our tests proved that for different agents we get different (logical) results, namely:

- A group where agents are mostly egoists (or totally) has worse results than a group where most of the agents are altruists.
- The existence of agents with higher levels of egoism in a group, even if the group is balanced, will jeopardize the group's results.
- Groups where agents are more influenced and/or attracted by the group, cooperate more and have fewer individual actions.
- A single agent's performance in the group is dependent on the group's constitution and its characteristics. An egoistic agent in an altruistic group is in clear advantage. An altruistic agent in a group of egoists probably loses all games. A neutral agent in a group with two altruistic agents and two egoists will lose to the egoists and win to the altruists.
- The results also proved the influence of a single agent in a group. The influence in group's performance is more noticeable for a single altruist in a group of egoists, with the altruist being sacrificed for the group's success. The existence of a single egoist in a group of altruists showed that in this case the egoist is in clear advantage over the other agents, using their work for the increase of his own well-being.

The analysis of the tests' results showed that the differences in egoistic level are noticeable by the behavior and the results not only on group level, but also on agent level, proving the efficiency of our model.

Our thesis successfully implemented a model for agents to deal with the choice between an individual and a group goal. The results of the executed tests showed that this choice can be based in psychological and sociological factors. Our test scenario, although simple, suggested that our model achieves logical results when we control the factors influencing the agents' choice.

## 8.1 Future Work

There were some open issues in our dissertation which we believe may be relevant for further research. The following list introduces such issues:

- It would be interesting to test the model with human users. Different users could play the game and answer a questionnaire where they should answer about how believable the autonomous agents' behavior is, and how interesting it was to use our model. These tests were planned in the beginning of the thesis, but weren't executed by lack of time. It would also be

interesting make a Turing Test, where users in different computers (and different physical space) would play in groups with other humans and autonomous agents. We could assert if the agents were able to "confuse" human users, or if they could easily understand which characters were autonomous and which were controlled by other humans.

- Power Pentagram is a simple, academic game. The system could be tested in a more commercial game. For instance, in a RPG [26] where a guild was sent in quests where they have the need to defeat an enemy and catch individual items, for instance. It would be interesting to test the agents implementing our model in a more complex environment.
- The model could also be implemented in other applications, like a life simulation game, where once adapted to a society and not simply a group, we could access its results in longer terms.
- The system could be expanded with more psychological and sociological factors that also affect humans. This way, we could achieve a behavior even more believable.
- The agents implementing our system have a simple planning algorithm allowing them to decide which actions are appropriate to achieve a given goal. It would be interesting to implement other planning mechanism which would allow the agent to execute some strategic thinking on which objective to pursue at a given time. This algorithm would consider the agents' points in the game, its adversaries' points or the time until the end of the level, among other factors. According to this algorithm's output, the agents' motivations to the individual and group's goals would increase more or less.
- In our system, when an agent is motivated to act, it uses a gem for his own well-being. When there is no such gem in the group's stash, the agent does nothing. It would be interesting to have an individual action which is not dependant on the existence of gems for the agent to act individually. This action should clearly prejudice the group, benefiting the agent. This way, we could access if the agents' individual actions harm the group without them being dependant on anything, and always being ready to trigger.
- In the case where the agent does nothing because of the lack of a gem in the group's stash, it would be interesting to have a planning algorithm allowing the agent to make a plan to get the needed gem.

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