Social Intelligence in Virtual Groups

Rui Prada and Ana Paiva

IST-Technical University of Lisbon and INESC-ID
Avenida Prof. Cavaco Silva - Taguspark
2744-016 Porto Salvo, Portugal
{rui.prada,ana.paiva}@gaips.inesc.pt

Abstract. Autonomous virtual agents have the potential to promote social engagement of users in virtual environments, thus enhancing their interaction experience. This effect is supported by the interactions users and virtual agents perform together. These interactions are often in group scenarios, where both users and agents perform collaborative tasks.
However, in order to have successful group interactions, it is not enough to assure that the characters behave in a coherent manner from an individual perspective, it is also necessary that they exhibit behaviours that are coherent with the group's composition, context and structure.
Furthermore, nurturing social intelligence in virtual agents has been a major concern in the community of multi-agent systems, specially to endow them with skills to perform well in group tasks. However, when building agents to interact in group with users, to perform well in the task does not, necessarily, assure a good interaction experience. While, it is true that users expect the members of their group to perform well in the task, they also expect believable dynamics of the interpersonal relations.
In this chapter, we will present a model (SGD Model) to support the dynamics of group interactions that incorporates task related interactions as well as social emotional ones. The model defines the knowledge that each individual should build about the others and the group, and how this knowledge influences its action decision. We will also describe a study that was performed to assess the effect of the SGD Model in the interaction experience of users while playing a collaborative game with virtual counterparts.

1 Introduction

Autonomos synthetic characters are very useful to improve the interaction experience of users with virtual environments because they can foster the social context of such experience [7]. Therefore, they have been used in many different domains, for example, to improve educational aplications [24] [27] or to produce interesting entertainment experiences [18] [10]. They are particular important in computer games, since they constitute the main driving force to create sucessfull narrative experiences, which are important to improve gameplay [28] [17].

To create sucessful autonomous synthetic characters means to make them believable, thus, to give them the ability to create the "illusion of life" in the eyes

of the viewers and lead them to the suspension of disbelief [8]. In other words, autonomous synthetic characters must be coherent with the users' expectations. These expectations concern different issues. For example, users expect the characters to expresss a consistent personality, to reacting emotionally to important events and to behave according to the social context of the interaction.

The work here presented explore some of the issues of the influence of social context in the believability of autonomous synthetic characters. Namely, interactions in groups constituted simultaneously by users and autonomous members. The work is focused on groups with few members (small groups), that are committed to a collaborative task and that does not present a strong organizational structure. Thus, we are not concerned with groups as crowds or complex societies. In addition, the goal is to engage users, as well as the autonomous characters, as active members of the group.

The problem is that, usually, the autonomous characters lack the necessary social skills to sucessfully interact in group, for example, they are not able to exhibit behaviours that are coherent with the group's composition, context and structure. For this reason, their role in the group is, usually, very restricted and their autonomy is limited. For example, in Role Playing Games, where the user interacts with a group of several characters in order to solve the challenges of a fantasy world, the autonomous characters only take secondary roles, such as a salesperson, while the main characters are controlled by the user.

To tackle this problem we developed a model to support the behaviour of autonomous characters that interact in group (the SGD model) that allows each individual character to reason about the others and the group. This model was inspired by theories of group dynamics developed in human social psychological sciences and is driven by a characterization of the different types of interactions that may occur in the group, taking into account the socio-emotional interactions as well as the task-related ones.

To test the effects of the model in the interaction experience of users, it was implemented in the behaviour of autonomous synthetic characters that collaborate with a user in the resolution of tasks within a virtual environment in the context of a collaborative game called Perfect Circle. The game was used in a study that showed that the model had a positive effect on the users' trust and social identification with the group.

In this chapter we start by discussing some related work concerning the interaction of autonomous characters in group. Then, we present the SGD model and, afterwards, the Perfect Cicle game. Next, we describe the experiment that was conducted to assess the effects in the users' interaction experience and its results and finish with some conclusions.

2 Related Work

The problem of multiple autonomous synthetic characters that interact as a group in virtual environments has been previously addressed by several researchers. The first example of this can be found on Reynolds' Boids [25], which

implements a flocking behaviour in a group of flying creatures (figure 1). In the same line of work we can additionally find research concerning the generation of crowds [22] that is often used in commercial systems for film creation. One well known example of this is "The Lord of the Rings" trilogy [23] that include numerous fighting scenes involving armies of thousands of warriors, the major part of these being played by synthetic actors.

Fig. 1. Boids. A snapshot from Stanley and Stella in: Breaking the Ice.

The Boids' flocking behaviour and crowd generation make use of an emergent group dynamics and result in a believable life-like group behaviour. However, characters in these examples do not have a deep social awareness and lack the ability to build social relations, which we believe to be essential for the interaction with a user.

Another example is the AlphaWolf system [31], which simulates the behaviour of a pack of six grey wolves (figure 2). In this system, the different synthetic characters are able to build domination-submission relationships. These relations are built in the form of emotional memories that drive the characters' behaviour. In addition, three users can interact with the system and influence the behaviour of three of the wolves. According to the authors, AlphaWolf has successfully implemented a believable simulation of the group interactions in a pack of wolves, and has engaged the user in such interactions. However, users and the synthetic characters do not engage in the resolution of a collaborative task and do not have a strong notion of group.

Schmitt and Rist [29] developed a model of virtual group dynamics for small group negotiations (figure 3). In their system, users delegate the task of scheduling their appointment meetings to a virtual character. Characters will then meet in an arena and together negotiate the meetings' times and dates. Each character has an individual personality and builds social attraction relations with the others. These relations and personality guide the characters' interactions and support the generation of the negotiation dialogues. In the end, the dialogues

Fig. 2. AlfaWolf. The black pup is dominating the white pup.

are played for the users. The believability of the group dynamics is a key factor in this example as it supports the believability of the characters' dialogues. But, users do not directly engage in the group interactions they are just played for them.

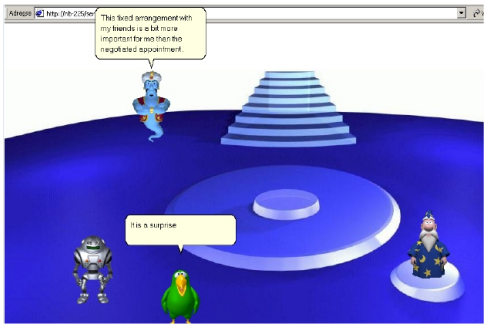

Fig. 3. Snapshot of the Avatar Arena taken during the display of a generated negotiation dialogue.

STEVE [27] is an example of a system where the users engage with a group of synthetic characters in a collaborative task (figure 4). It is used in a navy facility to train a team to handle possible malfunctions that may arise in a ship. The team can be composed of several human users and several virtual characters, which interact in a 3D virtual environment that simulates the ship and its equipment. In this scenario, the autonomous characters sucessfully engage in collaborative group activities with users, however, all interactions between the

group members are related to the task and there is not the possibility for deeper social engagement.

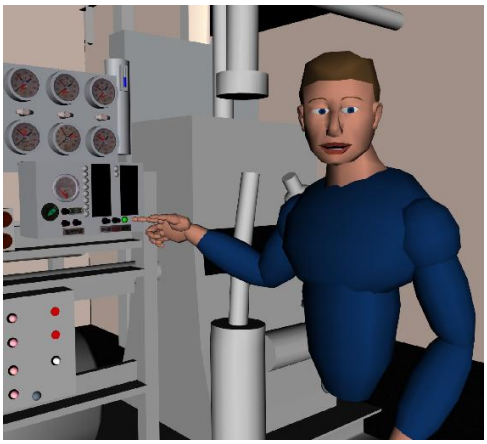

Fig. 4. STEVE pointing out a power light to a student.

In Demonstrate! [26] Rhalabi explore the use of emotions and personality to make the decions in a group, based on the Iterated Prisoner's Dilemma [5], in order to make the group more belieavable. The scenario explored represents a gathering of people in the street to make a political demonstration (figure 5). The user controls the leader of this group and as s/he proposes an action, the autonomous charaters will choose to either cooperate or defect, based on their personality and emotions. This system, engages the user in a group of autonomous characters but has the limitation of not allowing the autonomous members to take the role of the leader.

Furthermore, Computer Role Playing Games (RPGs), such as "Star Wars: The Knights of the Old Republic"[9] (figure 6) or "Neverwinter Nights"[13], are systems that engage the users in a group with autonomous synthetic characters that perform a collaborative task. But, since the social interactions have an important role in this type of games, specially those that take place between the members of the group, and since the social skills of the autonomous characters are usually weak they only perform simple roles and are not deeply involved in the group task. Additionally, players frequently have some control over the autonomous characters, which reduces their autonomy. For example, in the "Star Wars: Knights of the Old Republic" the player starts the adventure with one character, but, as the game evolves, other characters join the player's quest and s/he will end up controlling simultaneously an entire party of several characters. This fact decreases the players' perception of the synthetic members as individuals and increases the distance between the player and her/his character, which makes the players' interaction experience in the group less interesting.

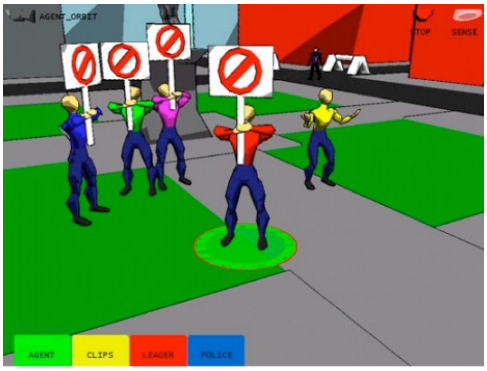

Fig. 5. A snapshot from Demonstrate!.

Fig. 6. A snapshot from "Star Wars: The Knights of the Old Republic".

3 SGD Model: A Model for Group Believability

The model we propose to support the believability of autonomous characters' behaviour in group, the SGD Model (Synthetic Group Dynamics Model), was build on the principle that each member of the group must be aware of the other members and the group itself. And, in addition, s/he should be able to build proper knowledge regarding the group's social structure and to use this knowledge to drive her/his behaviour.

The group is modelled as a system composed of several autonomous agents that engage in interaction processes. These interactions create the dynamics of the system. They have effects on the group's state and, at the same time, are influenced by that state. In other words, the preconditions for the occurrence of an interaction depends on the state of the group and the occurrence of an interaction will change, for example, the social structure of the group. For the definition of these interactions and their dynamics we have relied on theories of

group dynamics developed in human social psychological sciences, in particular [11], [6] and [20].

In concrete terms, the the SGD Model was created as a module that influences the usual processes of a cognitive agent. Thus, the model influences the perception, knowledge building, behaviour and action processes of each agent (see figures 7).

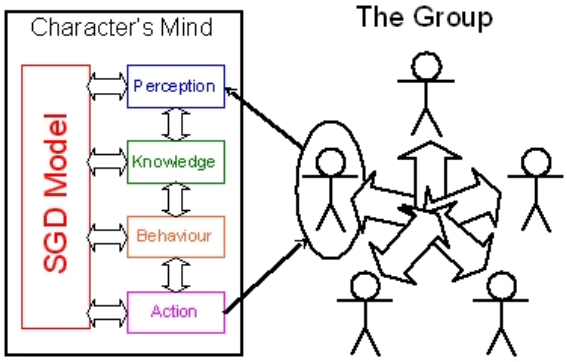

Fig. 7. The SGD Model in the mind of each member of the group.

3.1 Target Groups

There are several definitions and types of groups. For that reason, we would like to clarify which kind of groups does the proposed model applies to, before entering in more details in its description.

As discussed before, our study is focused in groups that involve a human user with several synthetic characters. These groups perform in a virtual environment and their members are committed to solve collaborative tasks. Thus, the group interactions must evolve in such a way that make the resolution of those tasks possible.

In addition, the model applies to small groups, with only a few members, and without a strong organizational structure. We are not concerned with groups as crowds or complex organizations and societies of agents.

The members of the group are implemented as autonomous software agents that can engage into conversation and can manipulate objects in the virtual environment (e.g. get, give, use and drop items). The user is represented as an agent (avatar) in the system that is not autonomous but fully controlled by the user.

3.2 The SGD Model Components

The SGD Model is characterized in four different levels:

1. **the individual level** that defines the individual characteristics of each group member, such as their personality;
2. **the group level** that defines the group and its underlying structure;
3. **the interactions level** that defines the different classes of interactions and their dynamics;
4. **the context level** that defines the environment and the tasks that the agents can perform.

These four levels represent the knowledge that agents should build in order to implement the SGD Model in their behaviour. Furthermore, in addition to this knowledge, the agents' behaviour in the group relies on three processes:

1. **Classification of the Interactions:** the agent is aware of the actions in the group and classifies them into categories of interaction with specific semantics. For example, in this process the agent interprets if certain actions are helpful for the group of not. This process uses the information on the four levels of the agent's knowledge, specially on the interaction level, that defines the possible categories of interaction, and in the context level that defines how should the actions of the group be interpreted, for example, by means of social norms.
2. **Propagation of the Interaction Effects:** then, based on the identified category, the interaction produce some changes on the knowledge, in particular in the individual and group level. For example, the interaction may change the social relations established between the members that it engages.
3. **Influence of the Agent's Actions:** finally, the agent's perception of the group and its members influences the actions that if performs in the group. For example, if the agent is not motivated it will not try to solve the group's tasks.

3.3 The Individual Level

The individual level defines the knowledge that the agent build concerning the individual characteristics of each of the members of the group. This knowledge defines the members' abilities and their personality:

1. **The agent's abilities:** define the actions that each agent can perform in the environment associated with their levels of expertise (e.g. how good the agent is while performing each of these actions). The set of abilities is important to determine the agent level of expertise in the group, which is an important factor to define the agent's position in the group.
2. **The agent's personality:** we define the agent's personality using two of the dimensions proposed in the Five Factor Model [19]: *Extraversion* and *Agreeableness*. We only consider these two dimensions because they are associated with the ideas of dominant initiative and socio-emotional orientation proposed by Bales [1] while the other dimensions are more related to the task resolution which is not our main focus.

(a) *Extraversion:* is related to the dominant initiative of the agent. Thus, it will influence the agent's frequency of interaction.
(b) *Agreeableness:* is related to the socio-emotional orientation of the agent. It defines the type of socio-emotional interactions that the agent will favour. More agreeable agents will favour positive socio-emotional interactions, while less agreeable agents will favour negative socio-emotional interactions.

4 The Group Level

The group level defines the knowledge that the agents build concerning the group and its underlying structure, and additionally the agents' attitude towards the group.

First of all, the group is defined as a set of individuals that follows the definition presented in the previous section. But, more than just a set, the group is a unique and identifiable entity with an inherent structure. A group is defined by:

1. **The group identity:** identification is an important factor in the definition of a group. For that reason the group needs a unique name to allow it to be clearly distinct in the environment and enable the agents to recognize it and refer to it.
2. **The composition:** the composition is the set of individuals that are associated with the group. The composition may change over time as new members may be admitted or excluded.
3. **The structure:** the group structure is defined in different dimensions. According to Jesuino [16] the most common are the structure of communication, the structure of power and the structure of interpersonal attraction (sociometric structure [21]). As we are handling small groups the structure of communication should not be complex, since all characters may communicate directly with each other, thus, we decided not to include it in our model. The group structure is then defined in two dimensions: the *structure of power* that emerges from the members' social influence relations, and the *structure of interpersonal attraction* that emerges from the members' social attraction relations.

Furthermore, since the group's structure emerges from the social relations established between its members, the group characterization also depends on the definition of these social relations. Which, as said before, can be of two different types:

1. **Social attraction:** these relations define the interpersonal attraction of the members in terms of like (positive attraction) and dislike (negative attraction) attitudes. These relations are unidirectional and not necessarily reciprocal (e.g. if agent A has a positive attraction for agent B, this does not necessarily mean that agent B has a positive attraction for agent A).

2. **Social influence:** relations of influence define relations of power, they quantify the capacity of one agent to influence the behaviour of another. The influence is defined as the difference between the power that one individual can exert on another and the power that the other is able to mobilize to resist [14].

In addition, a member's social relations in conjunction with its level of expertise determine its position in the group. This position reflects the member's relative significance in the group which defines how important its contributions are and how well are they accepted by the group. For example, actions performed by members that have more social influence on the group members have stronger effects on the group process. Thus, the group position defines the agent's relative power in the group, which directly depends on (1) the overall social influence that the agent may exert on the others, (2) the attraction that the others feel for the agent and (3) the agent's relative expertise in the group.

4.1 The Interactions Level

The interaction level describes the knowledge that the agent builds concerning the group's interactions and their dynamics. This dynamics reflects, on (1) the changes that the group's interactions induce in the agent's perception of the group and, therefore, in the knowledge it builds about the group, and (2) in the rules that drive the behaviour of the agent in the group.

The central notion in the interactions level is the concept of *interaction*. An *interaction* occurs when agents execute actions that can be perceived and evaluated by others. In fact, it may consist on several actions that are performed in a certain pattern. These actions can be performed simultaneously, which means that more than one agent may be involved in the same *interaction*. In addition, other agents may support the *interaction* but not be directly involved in its execution. For example, agents may agree with a certain *interaction* and explicitly show their support for its execution without performing a single action concerning the *interaction* other than the declaration of support.

Moreover, each *interaction* has a certain strength in the group that defines its relative importance in the group process. Additionally, each *interaction* may affect only certain members of the group. For example, when a member of the group encourages another to perform a task, the effects of the encouragement will only be reflected on the agent that was encouraged. The strength of an *interaction* in the group is directly related to the position in the group of the *interaction*'s performers and supporters.

The Classification of the Interactions In order to model the dynamics of the group process we have divided the several possible group interactions into different categories. This categorization is then embedded in the knowledge that the agent has a priori. It will support the agent's process of perception and identification of the interactions when it asserts new interaction facts in its knowledge base.

Furthermore, although the interaction is closely related to the actions that the agents perform, its classification is more than just the classification of the actions themselves. It depends on the actions' results, on the context of the execution, and also on the agents' perception of the group. Thus, for example, the same action can be perceived as a positive interaction to the group by an agent but as a negative by another.

The classification that the SGD Model presents was based on the categories that Bales proposed on his IPA system [6]. Thus, it follows the same main distinction between socio-emotional and instrumental interactions, and divides the interactions into positive and negative.

On the socio-emotional level we use six categories similar to those presented by Bales. We consider three positive socio-emotional interactions (*agree, encourage and encourage group*) and three negative social emotional interactions that are opposed by symmetry (*disagree, discourage and discourage group*).

- Positive socio-emotional interactions
  1. **Agree:** This class of interactions show the support and agreement of an agent towards one of the interactions of another agent consequently raising the importance of that interaction in the group.
  2. **Encourage:** These interactions represent an agent efforts to encourage another agent, consequently facilitating its social condition (e.g. increasing its motivation).
  3. **Encourage Group:** This class of interactions are similar to those in the *Encourage* category but apply to the group itself. These interactions encourage the group and facilitate the group's social structure (e.g. its cohesion).
- Negative socio-emotional interactions
  1. **Disagree:** This class of interactions show disagreement of an agent towards one of the interactions of another agent, consequently decreasing the importance of that interaction in the group.
  2. **Discourage:** These interactions represent an agent's hostility towards another agent and its efforts to discourage it.
  3. **Discourage Group:** This class of interactions are similar to those in the *Discourage* category but apply to the group itself. These interactions discourage the group and raise the entropy of its social structure.

The categories proposed by Bales at the instrumental level focus mainly on speech acts. And, in addition, there is not a clear connection between the instrumental interactions an the task itself. However, in the context of virtual environments, the interactions that are not based on speech acts are very important because the agents may manipulate the objects defined in the environment. Also, the design of the interactions' influence on a problem solving group and its members is easier if the interactions' definition is based on the concept of "problem". Therefore, following these two principles we defined four instrumental interactions: two positive (*facilitate problem, gain competence*) and two negative (*obstruct problem, loose competence*), that do not have a direct correspondence in the IPA instrumental categories.

– Positive instrumental interactions
  1. **Facilitate Problem:** This class of interactions represents the interactions of an agent that solves one of the group's problems or facilitates its resolution.
  2. **Gain Competence:** These interactions make an agent more capable of solving a problem. This includes, for example, the learning of new capabilities or the acquisition of information and resources.
– Negative instrumental interactions
  1. **Obstruct Problem:** This class of interactions represents the interactions of an agent that complicates one of the group's problems or makes its resolution impossible.
  2. **Loose Competence:** These interactions make an agent less capable of solving one problem. For example, by forgetting information or loosing the control of resources.

The Interactions' Dynamics As stated before, the interactions create the dynamics in the group. Such dynamics are supported by the classification presented in the previous section 4.1 and are modelled by a set of rules that follow the ideas found in the social psychological theories of group dynamics, like for example, the theory of social power by French and Raven [14] and Heider's balance theory [15]. These rules define, on one hand, how the agent's and the group's state influence the occurrence of each kind of interaction and, on the other hand, how the occurrence of each type of interaction influences the agent's and group's state.

During the group process, each member observes the actions that are being executed by the others and tries to identify patterns that match each of the proposed categories. This classification is done according to the current context and depends on the individual view of each member. Thus, for example, if two members have different views concerning the group's tasks, some actions may be perceived by one member as helpful to the resolution of these tasks and, therefore, classified as *FacilitateProblem* but can be perceived by the other as disadvantageous and, therefore, classified as *ObstructProblem*.

Furthermore, when members identify the occurrence of one interaction, they react to it according to the classification that they internally gave to the interaction. These reactions are translated into changes on the perceived knowledge of the group, specially in its structure. *Instrumental* interactions are related to changes in the relations of *social influence*, thus, each member that is responsible for positive *instrumental* interactions will raise her/his *influence* over the others and will decrease it in the case of a negative *instrumental* interactions. In turn, *socio-emotional* interactions are related to changes in the relations of *social attraction*, thus, each member that is target of a positive *social-emotional* interaction will raise her/his *attraction* for the performers and will decrease it in case of a negative *social-emotional* interaction. The *motivation* of the members involved in the interaction may also improve in the case of positive interactions and decrease otherwise. These rules are resumed in table 1.

Interaction	Mot(P)	Mot(T)	SI(P,T)	SA(T,P)
Pos-Instr(P,T)	+		+	
Neg-Instr(P,T)	-		-	
Pos-SocEmot(P,T)		+		+
Neg-SocEmot(P,T)		-		-

Table 1. The effects of the interactions on motivation (Mot), social influence (SI) and social attraction (SA). P denotes the member that performs the interaction and T the target of the interaction. The symbols in the table define if the value increases of decreases.

Moreover, in order to keep the social relations balanced [15], the *social-emotional* interactions may have effects on a member of the group this is not directly involved in the interaction. For example, imagine that John is encouraging Frank because he failed to perform a certain task and Mary observed this event. Mary knows that Frank will increase his social attraction for John and this will lead to changes in her own relation with the two. For instance, if Mary has a positive relation with Frank then her relation with John may improve. But, if, on the other hand, she has a negative relation with Frank then her relation with John may become worse. Table 2 resumes these rules.

Interaction	SA(O,T) > 0	SA(O,T) < 0
Pos-SocEmot(P,T)	+	-
Neg-SocEmot(P,T)	-	+

Table 2. The effects of the interactions on the social attraction of an observer. The values on the table reflect the changes on SA(O,P). The symbols in the table define if the value increases of decreases.

The intensity of the interactions' effects depends on the *position* in the group of the members that perform them. Thus, for example, encouragements performed by members with a better *position* will increment more the target's *motivation*.

The knowledge built regarding the group, in its three different levels, regulate the behaviour of the member in the group. This is reflected in a set of conditions that determine the frequency of occurrence of each type of interaction. These conditions depend on individual characteristics, such as *motivation* and *personality*, and on the social structure of the group [30] [20] [1].

Table 3 resumes the influence of each of these variables regarding the four main categories of interaction. For example, the first three lines express the general rules for the frequency of all types of interaction, which state that: *"highly motivated agents engage in more interactions, as well as agents with a good position in the group or high extraversion"*. Another example, concerning the social relations, is expressed in line 7, which states that: *"a character will engage in more positive socio-emotional interactions towards members that have influence*

over him". Note that decisions are probablistic. The abovementioned rules only suggest the frequency of interaction. Thus, for example, a less motivated agent can perform tasks, but not very often.

Variable	**SE-Pos**	**SE-Neg**	**I-Pos**	**I-Neg**
Motivation(P)	+	+	+	+
Extraversion(P)	+	+	+	+
GroupPosition(P)	+	+	+	+
Agreeableness(P)	+	-		
GroupPosition(T)	+	-		
Influence(P, T)	-	+		
Influence(T, P)	+	-		
Attraction(P, T)	+	-		
Skills(P)			+	-

Table 3. The influence on the four major categores of interactions: Socio-emotional positive (SE-Pos), Socio-emotional negative (SE-Neg), Instrumental positive (I-Pos) and Instrumental negative (I-Neg). The symbols in the table define if the value increases of decreases.

5 The Perfect Circle Game

To test the effects of the SGD Model we have developed a collaborative game called "Perfect Circle: the Quest for the Rainbow Pearl"[1] and implemented the SGD Model in the mind of the autonomous characters of that game.

The game takes the user into a fantasy world where he joins a group of four other characters to search the world for a magic item. To achieve this, the group must travel around the world through magic portals that are activated by the powers of some gemstones. Their task is to gather and manipulate the gemstones in order to get the required ones that will open the portal (see figure 8). To achieve this, characters need to apply their individual abilities in order to change the gems' form, size and colour. For example, if the group has two small rubies but it needs one medium sized ruby, one character can use its ability to merge the small stones into a bigger one. In addition, two or more characters can combine their efforts if they all have the same ability. As a result, the probability of success of the action becomes higher.

Furthermore, every character in the group is engaged in the same goal, thus trying to solve the same task. However, there are many ways to reach a solution, and if each of the characters follows its own, the group may never solve the task. Thus, characters have to coordinate their actions in order to follow a similar strategy in the search for the correct gems to activate the portal.

For this reason, every action that is performed in the group, concerning the resolution of the task, is discussed by the group beforehand. The discussion protocol has three different steps:

[1] This game can be downloaded from *http://web.tagus.ist.utl.pt/˜ rui.prada/perfect-circle/*.

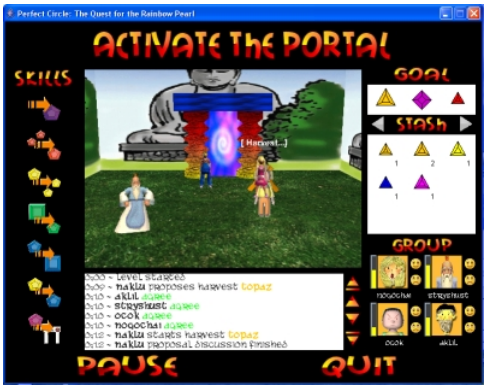

Fig. 8. The group is trying to activate one of the portals in order to move further.

1. First, one character declares that s/he wants to take a certain action (e.g. *"I think that it will be best if I merge these two sapphires"*).
2. The other characters can respond to the proposal with one of the following: (1) *Agree* with the course of action; (2) *Join* the action and help in the execution; (3) *Disagree* with the course of action.
3. Then, based on the opinions expressed by the group, the character decides to proceed with the execution of the action or to withdraw the proposal. If s/he decides to proceed with the action then s/he starts its execution. All other characters that have decided to join the action start their contributions to the joint execution.

Furthermore, the group interactions are not restricted to the execution of the task. Each member can, at any time, engage in social-emotional interactions by encouraging or discouraging the other members of the group. For example, if one character just messed up the task the others can discourage her/him and tell her/him to stop trying or, on the other hand, may encourage her/him tell her/him that if was just bad luck.

6 Study

To evaluate the effects of the SGD Model in the interaction experience of users we have conducted an experiment was at our university with 24 students of computer engineering, being 20 of them male and 4 female. The subjects' age ranged between 19 and 31 years old.

6.1 Independent Variables

The experiment was conducted with two main independent variables: the use of the model SGD Model to convey the believable group dynamics and the initial structure, and consequent cohesion level, of the group.

1. **The Use of the model:** SGD Model two different versions of the game were built: one where the characters followed the model SDG Model and other where they did not. When the characters did not use the model they were not able to engage in socio-emotional interactions, except *Agree* and *Disagree* (without any socio-emotional connotation). In addition, their frequency of interaction was always constant and the decision to proceed with a proposed action was not weighted by the members' position in the group, it was a simply majority rule.
2. **The Group's Initial Structure:** subjects can start the game in a group with non neutral initial social relations, which means that the initial group can have levels of cohesion that may be either very high or very low. Two different scenarios were considered: one where the group had neutral social relations and a second one where the members of the group disliked each other, which, took the group cohesion to very low levels. Note that this condition could only be applied when the game was run with the believable group dynamics model.

6.2 Dependent Variables

To assess the quality of the subjects' interaction experience while playing the game we have measured their satisfaction with the game as well as their trust and social identification with the group, since, according to Allen et al. [2] these two variables are related to the satisfaction of people when interacting in group. Thus, the three dependent variables are:

1. **Group Trust:** people's trust on a group has a positive effect on their perceptions about their experience in the group [12], which consequently leads to a more satisfactory interaction [3].
2. **Group Identification:** according to Ashforth and Mael [4] social identification is, in addition to social trust, one of the factors that foster the members of a group to be more engaged and more satisfied with the group.
3. **Satisfaction with the Game:** computer games are supposed to be fun, thus, the user should enjoy every moment that s/he spends with the game. Hence, to improve the interaction experience, as stated in the initial hypothesis, would imply also to increase the user's fun.

6.3 Procedure

The experiment was divided into four sessions of two hours each. In each session we had six different participants each on a different computer with the *Perfect Circle* game installed. The game was installed according to three different conditions (two computers for each condition):

(C1) In the first condition the game was installed without our model for believable group dynamics.

(C2) In the second condition the game was installed with the model and the group had neutral social relation in the beginning of the game.

(C3) In the third condition the game was installed with the model but the members of the group started with negative social attraction relations, thus, the level of cohesion of the group was very low.

Furthermore, apart from the differences mentioned, all the other details were similar for the three conditions. The four autonomous characters had the same name, the same appearance, the same personality and the same skills. In addition, the sequence of the game puzzles was predefined and the same for all the subjects. This sequence was randomly generated beforehand. The subjects were selected on the fly in the beginning of each session and they chose freely which computer to use. Subjects played the game for one and a half hour and at the end were requested to fill a questionnaire.

This process was repeated in the four sessions, which in the end gave a sample of eight subjects for each of the conditions.

6.4 Results

Concerning the subjects' trust in the group we have reached some significant results. As shown in figure 9, the subjects who played the game with the SGD Model had more trust in the group than those who played without the model. Furthermore, the fact that the group was initially cohesive, or not, did not influence the final levels of trust.

Cond.	N	Mean Rank
1	8	7,31
2	8	15,19
3	8	15,00

Chi-square: 6,492; *Asymp. Sig:* ,039

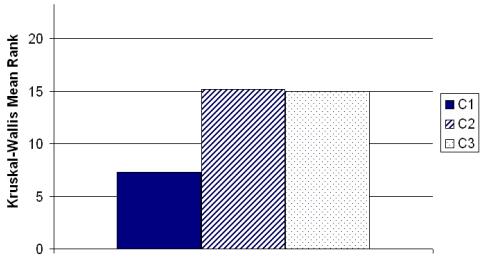

Fig. 9. The subjects' trust in the group across the three different conditions of the experiment.

The results regarding the subjects' identification with the group are similar to those verified concerning the group trust. Which means that the SGD Model also

had effect on the subjects' social identification with the group. Figure 10 shows these results and, as we can see, the identification with the group is higher in the two conditions where the synthetic characters used the SGD Model to drive their behaviours.

Cond.	N	Mean Rank
1	8	8,00
2	8	12,94
3	8	16,56

Chi-square: 5,960; *Asymp. Sig:* ,051

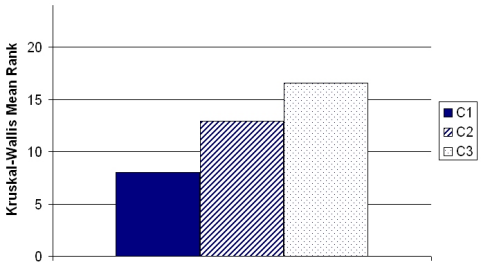

Fig. 10. Subjects' identification with the group across the three different conditions of the experiment.

In addition, there are differences in the social identification in relation to the initial group cohesion. It seems that the most cohesive group induced lower levels of identification in the subjects. We believe that this effect may be related to the fact that the socio-emotional interactions in the highest cohesion group are essentially positive, which is probably less believable than a scenario where both, positive and negative, socio-emotional interactions occur, as in the case of the third condition.

Concerning the subjects' satisfaction with the game, we reached some interesting results. As figure 11 shows, the general satisfaction was the highest in the case of the third condition but it was the lowest in the case of the second condition.

This effect is surprising as it contradicts, in a certain way, the other results, since the effects of the SGD Model were always positive in the case of the other two variables. Nevertheless, in the third condition, where the group was initially non cohesive, the positive effect still applies to the satisfaction with the game. Thus, there was a particular element of the second condition that did not please the players. Our hypothesis is that, since the socio-emotional interactions in a cohesive group are more likely to be positive, the subjects did not find the group itself to be challenging, and therefore were more bored with the group

interactions. However, with this study we can not confirm this hypothesis with confidence.

Cond.	N	Mean Rank
1	8	12,94
2	8	8,56
3	8	16,00

Chi-square: 4,503; *Asymp. Sig:* ,105

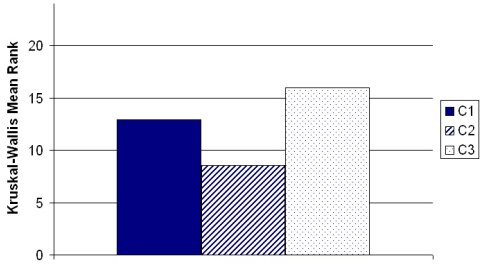

Fig. 11. Subjects' general satisfaction with the game across the three different conditions of the experiment.

7 Conclusions and Future Work

In this chapter we argued that group believability of synthetic characters is important, when among the group, we have characters and users interacting with each other, which is often the case of virtual environments. Then, to achieve such group believability, we have proposed a model inspired by theories of group dynamics developed in human social psychological sciences. The dynamics is driven by a characterization of the different types of interactions that may occur in the group. This characterization addresses socio-emotional interactions as well as task related interactions.

This model was successfully used in the context of a collaborative game, and the experiment conducted in that scenario demonstrated the positive effect that the model can have on the users' interaction experience, specially on the users' trust and identification with the synthetic group.

Furthermore, we found some evidence that that if the group starts with low levels of the cohesion players have more fun playing the game. This gives us some evidence that players might prefer playing in groups that have higher level of conflict.

References

1. S. Acton. Great ideas in personality - theory and research. *(online) http://www.personalityresearch.org/bigfive.html*, last access on Jan 2005.
2. K. Allen, R. Bergin, and K. Pickar. Exploring trust, group satisfaction, and performance in geographically dispersed and co-located university technology commercialization teams. In *Proceedings of the NCIIA 8th Annual Meeting: Education that Works*, March 18-20, 2004.
3. J. Ang and P. H. Soh. User information satisfaction, job satisfaction and computer background: an exploratory study. *Information and Management*, 32:255–266, 1997.
4. B. E. Ashforth and F. A. Mael. Social identity and the organization. *Academy of Management Review*, 14:2–39, 1989.
5. R. Axelrod. *The Evolution of Cooperation*. Basic Books, Inc., Publishers, New York, NY, USA, 1984.
6. R. F. Bales. *Interaction Process Analysis*. The University of Chicago Press, Chicago, 1950.
7. J. Bates. Virtual reality, art and entertainment. *Presence: teleoperators and Virtual Environments*, 1992.
8. J. Bates. The role of emotions in believable characters. *Communications of the ACM*, 37(7):122–125, 1994.
9. Bioware. Star wars: Knights of the old republic. *(online) http://www.bioware.com/games/knights_old_republic/*, 2003.
10. B. Blumberg. (void*): A cast of characters. In *Visual proceedings of the conference on SIGGRAPH 99*, page 169. ACM Press, 1999.
11. D. Cartwright and A. Zander. *Group Dynamics: research and Theory*. Harper and Row, New York, 1968.
12. J. W. Driscoll. Trust and participation in organizational decision making as predictors of satisfaction. *Academy of Management Journal*, 21:44–56, 1978.
13. O. Entertainment. Neverwinter nights 2. *(online) http://www.atari.com/nwn2*, 2006.
14. J. R. P. French and B. H. Raven. *Group Dynamics: Research and Theory*, chapter Bases of Social Power. Harper and Row, New York, 1968.
15. F. Heider. *The Psychology of Interpersonal Relations*. Wiley, New York, 1958.
16. J. C. Jesuno. *Psicologia Social*, chapter Estrutura e processos de grupo: interaces e factores de eficcia. Fundao Calouste Gulbenkian, 2000.
17. C. A. Lindley. The gameplay gestalt, narrative, and interactive storytelling. In *Proceedings of Computer Games and Digital Cultures Conference*, pages 203–215, 2002.
18. C. Martinho and A. Paiva. Pathematic agents. In *Proceedings of the 3rd International Conference on Autonomous Agents*, Seattle, USA, 1999. ACM Press.
19. R. McCrae and P. Costa. *The five factor model of personality: theoretical perspectives*, chapter Toward a new generation of personality theories: theoretical contexts for the five factor model, pages 51–87. Guilford, New York, 1996.
20. J. E. McGrath. *Groups: Interaction and Performance*. Prentice Hall, Englewood Cliffs, New Jersey, 1984.
21. J. L. Moreno. *Who Shall Survive?* Nervous and Mental Disease Publishing Co., Washington D.C., 1934.
22. S. R. Musse and D. Thalmann. Hierarchical model for real time simulation of virtual human crowds. *IEEE Transactions on Visualization and Computer Graphics*, 7(2):152–164, 2001.

23. New-Line-Productions. The lord of the rings movies official site. *(online) http://www.lordoftherings.net*, 2001.
24. R. Prada, I. Machado, and A. Paiva. Teatrix: virtual environment for story creation. In *Proceedings of the Fifth International Conference on Intelligent Tutoring Systems*, Montreal, Canada, 2000. Springer.
25. C. W. Reynolds. Flocks, herds, and schools: a distributed behavioural model. In *Computer Graphics (SIGGRAPH '87 Conference Proceedings)*, pages 25–34, 1987.
26. A. E. Rhalibi, N. Baker, and M. Merabti. Emotional agent model and architecture for npcs group control and interaction to facilitate leadership roles in computer entertainment. In *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology*, pages 156–163. ACM Press, 2005.
27. J. Rickel and W. L. Johnson. Virtual humans for team training in virtual reality. In *Proceedings of the Ninth International Conference on AI in Education*, pages 578–585, 1999.
28. J. Schell. Understanding entertainment: story and gameplay are one. *Computers in Entertainment*, 3(1), 2005.
29. M. Schmitt and T. Rist. Avatar arena: virtual group-dynamics in multi-character negotiation scenarios. In *4th International Workshop on Intelligent Virtual Agents*, page 358, 2003.
30. M. E. Shaw. *Group Dynamics: the Psychology of Small Group Behaviour*. McGraw-Hill, New York, 1981.
31. B. Tomlinson and B. Blumberg. Social synthetic characters. *Computer Graphics*, 26(2), May 2002.