Synthetic Group Dynamics in Entertainment Scenarios

Creating Believable Interactions in Groups of Synthetic Characters

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ABSTRACT

Today, many interactive games and virtual communities engage several users and synthetic characters, all interacting in the same virtual environment. In addition, these interactive scenarios, often present tasks to the participants that must be solved collaboratively. However, to achieve successful and believable interactions between users and such synthetic characters, the latter must be able to show a coherent and set of behaviours. Thus, in scenarios where users and synthetic characters interact as a group, it is very important that the interactions follow a believable group dynamics. Focusing on this problem, we have developed a model that supports the dynamics of a group of synthetic characters, 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.

We have implemented the model into the behaviour of synthetic characters that collaborate with the user in the resolution of tasks within a collaborative game. This game was used in an evaluation experiment which showed that the model had a positive effect on the users' social engagement in the group, namely on their trust and identification with the group.

General Terms

Human Factors, Design, Experimentation

Keywords

Autonomous synthetic characters, group dynamics, collaboration, human-computer interaction

1. INTRODUCTION

Today, many interactive games and virtual communities engage several users and synthetic characters, all interacting in the same virtual environment. In addition, these interactive scenarios, often present tasks to the participants that must be solved collaboratively. For example, in computer role-playing games several players form parties of adventures that undertake the challenges and quests of the game's world.

However, in these collaborative group scenarios, the interactions between the users and synthetic characters will only be positive and effective if the characters are able to show a coherent and believable behaviour in the group. Believability was defined by Bates [5] as the ability to lead the user to the suspension of disbelief and highly depends on the richness of the characters' actions and expressions and how they meet the users' expectations.

Some research has been conducted on the believability issues of synthetic characters, however, it is usually centered on the interactions between a user and a single character [6] [18] or on the interactions of the synthetic characters among themselves [22] [19] without considering the user within the group and without a common collaborative task.

We argue that it is not enough to assure that the characters behave in a coherent manner from an individual perspective, but it is also necessary that they exhibit behaviours that are coherent with the group composition, context and structure, thus, following a believable group dynamics.

The synthetic characters often lack the social skills needed for such believable group interactions, which threatens their possibility to take an active and important role in the group. For example, usually, the synthetic characters play secondary roles in the game (e.g. a salesman) or are not fully autonomous and are under the control of the users. Thus, we believe that looking at "group believability" can improve the synthetic characters participation in the group and consequently improve the users' interaction experience.

To prove this argument we propose to enhance the role of these characters, making them part of the team. To do that we have developed a model for the dynamics of a group, inspired in theories developed in human social psychological sciences, that define the knowledge that each individual should build about the others and the group, and how this knowledge drives their interactions in the group.

We have implemented the model into the behaviour of synthetic characters that collaborate with the user in the resolution of tasks within a collaborative game. This game was used in an experiment conducted to assess the influence of the model on the users interaction experience. The results showed that the model had a positive effect on the users' social engagement with the group, namely their trust and identification with the group.

This paper is organized as follow. First, we discuss the problem of groups of synthetic characters in entertainment scenarios. Then, we will describe the model for the group dynamics and how it was embedded in the synthetic characters in the computer game. Afterwards, we describe the experiment and report the results. Finally, we draw some conclusions.

2. GROUPS IN ENTERTAINMENT

Computer games have evolved from single user to multi-user and in many cases have engage players and autonomous characters together in a team. One particular case of this are the Role Playing Games where players and some autonomous characters, form a group of heroes that undertake the quests of a fantasy world. In this type of games the social interactions are an important part of the game, specially those that take place between the members of the group. However, the characters usually lack the ability to engage in such social interactions, and, therefore, their role in the group is usually very restricted. Additionally, players frequently have some control over the characters, which reduces their autonomy. For example, in the "Star Wars: Knights of the Old Republic"[7], 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. For this reason, and in order to achieve a better the gaming experience, Role Playing Games are often played by several users each one controlling a single character. In these scenarios the autonomous characters are limited to the role of servants or companions that follow their masters and do not actively participate in the group. Thus, if a synthetic character can interact and collaborate in a natural way within a group of human players, it can take up a more active participation in the group, and play a central role in the group. Furthermore, in the absence of other human players, these synthetic characters may raise the gaming experience to the same levels of enjoyment as if there were only humans involved.

To achieve this, we believe that the synthetic characters should behave in a group in a similar way as humans do, thus, following a group dynamics inspired on human social studies. For this purpose, we have developed a model to support the creation of such group behaviour (see section 3).

The model applies to groups that involve a user with several synthetic characters that are committed to the resolution of collaborative tasks in a virtual environment. Furthermore, the model only considers groups with few members (small groups) and without a strong organizational structure. Which means that we are not concerned with groups as crowds or complex organizations and societies of agents.

The synthetic characters in such groups are built as autonomous cognitive agents that need the ability to engage in conversations in order to discuss with the group, and to manipulate objects in the virtual environment (e.g. get, give, use and drop items) in order to perform the necessary actions that solve the task. These agents are expected to be socially autonomous as discussed by Castelfranchi [9] in the sense that they have autonomy on their goals and their believes.

The user is represented as another agent (avatar) in the system that is not autonomous but completely controlled by the user.

3. A MODEL FOR THE GROUP DYNAMICS

The proposed SGD Model (Synthetic Group Dynamics Model) is based in the principle that each synthetic character must be aware of the group and its members and should be able to build a proper social model of the group and guide its behaviour in the group with it.

To build such a model we have relied on theories of group dynamics developed in human social psychological sciences, in particular [8], [4] and [17].

The model, defines a *group* as a system composed by several agents, which engage in interaction processes that drive the dynamics of the system. Agents themselves, apart from their knowledge of the task and their individual goals, also contain a model the group, which is characterized at four different levels: (1) the individual level, (2) the group level, (3) the interactions level and (4) the context level.

3.1 The Individual Level

The individual level models what each agent knows about the individual characteristics of the others. Each agent is modelled as a unique entity having a name that identifies it in the group, a set of abilities and a personality:

1. **Name:** identifies the agent in the group.
2. **Abilities:** define the actions that the agent can perform in the environment that may help the resolution of the group tasks.
3. **Personality:** we define the agent's personality using two of the dimensions proposed in the Five Factor Model [16]: *Extraversion* and *Agreeableness*; that according to Bales[1] are associated with the ideas of dominant initiative and socio-emotional orientation.

3.2 The Group Level

At the group level the model considers the group composition and identity and its underlying structure as well as the agents' attitude towards the group:

1. **Identity:** defines a way to distinguish the group in the environment (e.g. a unique name), thus allowing

its members to recognize and refer to it.

2. **Composition:** is the set of agents that belong to the group, its members. These agents must follow the definition presented in the individual level.

3. **Group Structure:** emerges from the relations established between the members and can be defined at different dimensions. According to Jesuino [15] these dimensions are: (1) the structure of communication; (2) the structure of power; and (3) the structure of interpersonal attraction. We have assumed that the structure of communication is simple (all agents communicate directly with each other) and therefore we will focus on the group structure only in two dimensions:

   (a) the *structure of power* that emerges from the members' social influence relations,

   (b) and the *sociometric structure* that emerges from the members' social attraction relations.

Furthermore, to define the group structure we must define the social relations established between all the group members. The agents have to model two different social relations:

1. *Social attraction:* relations of attraction are related to like (positive attraction) and dislike (negative attraction) attitudes. These relations are unidirectional and not necessarily reciprocal (if one 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 of power that one individual can exert on another and the power that the other is able to mobilize to resist [11].

In addition to the social relations that agents build with each other, agents also build a relation with every group that they belong to. This relation captures the member's attitude towards the group and supports the notion of membership. It categorizes the member in the group at two main levels:

1. **Motivation in the Group:** defines the level of engagement of the agent in the group's interactions and tasks.

2. **Position in the Group:** reflects the agent's relative significance in the group, thus, defining how important are its contributions to the group and how well are they accepted. For example, actions performed by agents that have higher positions on the group members have stronger effects on the group process. This depends on the overall social influence that the agent may exert on the others, on the attraction that the others have for the agent and on the agent's relative expertise in the group.

The agents' *position in the group* is computed using the following formula:

$$\begin{aligned} &\forall Group(G) \wedge A \in Members(G): \\ &Position(A,G) = SkillLevel(A,G) + \\ &\sum_{m \in Members(G)}^{m} SocialAttraction(m,A) \\ &+ \sum_{m \in Members(G)}^{m} SocialInfluence(A,m) \end{aligned} \tag{1}$$

Where *Group(G)* defines G as a group, *Members(G)* denotes the set of agents that belong to G, *SkillLevel(A,G)* denotes the relative skill level of the agent in the group, and *SocialAttraction(A,B)* and *SocialInfluence(A,B)* denote, respectively, the value of the social attraction that agent A has for the agent B and the social influence that agent A exerts on agent B.

3.3 The Context Level

The context level defines the knowledge that the agent builds about the environment where the agents perform and the nature of the group's tasks. One of these definitions is the task model, that allows the agent to interpret the group interactions in terms of their effects on the the task, and therefore allows the agent to classify them in the instrumental categories.

Additionally, the context may also define some social norms, that will guide the agent in the interpretation of the social-emotional interactions. The social norms define the acceptable behaviours and the misconducted interactions, thus, supported on these definitions one agent can check, for example, if one action that is directed to itself is a positive or negative socio-emotional interaction.

3.4 The Interactions Level

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

The central notion is the concept of interaction, which is related to the agents' execution of actions. An interaction is characterized by: the set of *performer*s that are responsible for the occurrence of the interactions; the set of *supporters* agree with the interaction and support it, but directly involve in its execution; a set of *targets* that are affected by the interaction; and the interaction *strength* in the group, which determines its relative importance in the group. The interaction's *strength* depends on the group position of the members that are responsible for its execution or have supported it.

3.4.1 The Classification of the Interactions

Type	Positive	Negative
Socio-emotional	*Agree, Encourage*	*Disagree, Discourage*
Instrumental	*Facilitate Problem, Gain Competence*	*Obstruct Problem, Loose Competence*

Table 1: The categories of interaction.

In order to model the dynamics of the group process we have classified the several possible group interactions into different categories. This categorization is then embedded in the knowledge that the agent has a priori and will support the agent's process of perception and identification of the interactions.

This 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 one agent but negative in the view of another.

The classification was based on the categories that Bales proposed on his IPA system [4]. Bales argued that members in a group are simultaneously handling two different kind of problems: those related with the group task and those related to the socio-emotional relations of its members. Based on this, in the model, the members interactions are divided into two major categories: the *instrumental interactions* (related to the group task) and the *socio-emotional interactions* (related to the group social relations). In addition, the interactions can be classified as positive, if they convey positive reactions on the others, or negative, if they convey negative reactions (see table 1).

The *socio-emotional* interactions fall into four categories: *Agree* and *Disagree* that show agreement (disagreement) for another member's interactions, which consequently raises (lowers) its strength in the group; and *Encourage* and *Discourage* that represents one members efforts to encourage (discourage) another member in the group.

The instrumental interactions, are defines as: *Facilitate Problem* and *Obstruct Problem* that represent the interactions made by one agent that solves (complicate) one of the group problems; and *Gain Competence* and *Loose Competence* that represent interactions that make one agent more (less) capable of solving one problem. This includes, for example, learning (forgetting) new capabilities, or the gain (loose) control of information and resources.

3.4.2 The Dynamics of the Interactions

The interactions create the dynamics in the group. Such dynamics is supported by the classification presented on the previous section and is modelled through a set of rules that follow the ideas found in the social psychological theories of group dynamics [20] [17] [11] [14].

These rules define, on one hand, how the agent's belief of group's state influence its behaviour, thus, define the conditions for occurrence of each kind of interaction, and on the other, define the effects of the occurrence of each type of interaction on the agent's and group's state.

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 2: The categories of interaction. P denotes the member that performs the interaction and T the target of the interaction.

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 3: The effects of the interactions on motivation (Mot), social influence (SI) and social attraction (SA).

The conditions for interaction depend on individual characteristics, such as the *motivation* and *personality*, and on the social structure of the group [20] [17] [1]. Table 2 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 group position or high extraversion. Another example, concerning the social relations, is expressed in line 7, which states that an agent will engage in more positive socio-emotional interactions towards members that have influence over him.

Furthermore, when agents get the perception of the execution of one interaction, they react to it according to the classification that they internally give to the interaction. These reactions are translated into changes on the perceived state of the group. These changes follow rules that are resumed on tables 3 4

Table 3 shows the correlation of socio-emotional interactions with social attraction and instrumental interactions with the relations of social influence. On table 4 are presented the rules that express Heider's balance theory [14], which relates the effects of a social-emotional interaction on a observer that is not directly target of the interaction. For instance, if one agent observes a positive socio-emotional interaction on an agent that it feels positively attracted to, then its attraction for the performer will increase.

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

Table 4: The effects of the interactions on the social attraction of an observer. The values on the table reflect the changes on SA(O,P).

Figure 1: The group of Alchemists is trying to activate one of the portals to move further in the planes.

The intensity of the interactions' effects described depends on the strength of the interaction in the group. Thus, for example, encourage interactions performed by members with a better position in the group will increment more the target's motivation.

4. THE TEST CASE

This model was used in the mind of agents that act as characters in a game called "Perfect Circle: the Quest for the Rainbow Pearl"[1]. The game takes the user into a fantasy world where he has joined a group of other four character 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. Thus, the group is progressively challenged with the task to open one portal (see figure 1). Their task is to gather and manipulate the gemstones in order to get the required ones that will open the portal. To achieve this, the 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 to use one ability if they all share 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 stones 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/*.

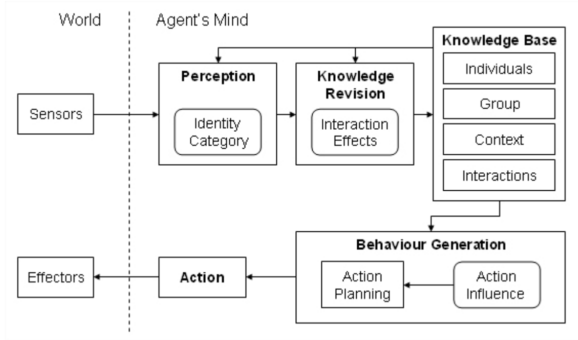

Figure 2: The SGD Model in the agents' mind.

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. 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.

The group interactions are not restricted to the execution of the task. Each member can at any time engage in social-emotional interactions by expressing their opinion about other members or the group.

5. IMPLEMENTATION DETAILS

The game was implemented in Java using Java 3D[21] for the 3D visualization of the environment. In turn, the synthetic characters' minds were implemented using a shell for Java that supports the creation of rule-base systems, the JESS[12] [13] shell.

The mind was implemented according to the architecture shown in figure 2. It consists in five main modules: the perception module, the knowledge base module, the knowledge revision module, the behaviour module, and the action module.

5.1 The Action Module

The action module translates the action requests from the behaviour module into concrete executions of the characters effectors. In our example, characters may execute seven different type of actions:

1. **Propose(A,G1, G2):** this is a speech-act action that starts the discussion in the group of a proposal for

action. A proposal describes the ability (A) and the gems to be used (G1, G2). E.g. "I propose to *merge* these *two rubies*.".

2. **Agree(P), Disagree(P), and Join(P):** these are speech-acts that characters use to express their opinions concerning the current proposal (P).

3. **Execute(A,G1, G2):** this starts the execution of a task action using an ability (A) with some gems G1, G2. For example, start to merge two gems together or start to use a gem on the magic portal. The success of the action depends on the character's skill level.

4. **Encourage(C), Discourage(C):** these are speech-acts that express encouragement or discouragement toward another character (C). For example, "Keep the good work." or "Stop messing up.".

5.2 The Perception Module

The perception module is responsible for gathering the information from the character's sensors and translate it into facts on the knowledge base. Its main function, concerning the SGD Model, is the identification of the group interactions as defined in section 3.4.1. The interactions are classified according to the actions that are observed.

In our example, the speech-acts Encourage, Discourage, Agree and Disagree are mapped directly to the corresponding group interactions, thus, not further inference is needed.

In turn, the identification of the instrumental interactions depend on the character's current plan and the success of the task actions. Therefore, an action will be interpreted as positive for the group - Facilitate Problem - if the action is in the character's plan and it succeed, and it will be interpreted as negative - Obstruct Problem - if it failed.

5.3 The Knowledge Base Module

The knowledge base module stores facts that represent the character's beliefs about the world. These include facts that define the individuals, the group state, the group interactions and the group task.

The individuals are characterized by facts that represent their abilities and their personality. Extraversion and Agreeableness are stored in values between 0 and 100 and abilities are stored in facts that define its name, the type of gems that they use and its skill level. E.g. *Ability(Character1, Merge, Ruby, 20)*. These attributes are public, thus, the perception module directly stores their values without any kind of inference.

Relations of social attraction and social influence are assessed by values that vary between -100 to 100. The zero value represents a neutral relation, while the lowest value represents its most negative state (e.g. hate the other) and the highest value represents the other extreme (e.g. love the other).

A character's motivation and group position is also assessed by values between 0 and 100. However, the group position is measured in terms of a percentage in the group and reflects a comparison with the other members. Thus, the sum of the values of each member's group position all together is always 100. This means that, for instance, in a group of five members with neutral relations, where each element have, initially, similar positions in the group, this value will be 20 for every member. In a group of two elements the value would be 50.

The values for the social relations, motivation and group position are not assessed directly from the perception module. They are a result of inference in the knowledge revision module.

In addition, the knowledge base store facts concerning the group task, namely the current goal, its state of achievement and the set of gems that the group have at each moment.

5.4 The Knowledge Revision Module

This module is responsible for updating the knowledge base. Its main functionality if to apply the interaction effects on the group state (see section 3.4.2).

For each new interaction this module computes the new values for the variables that the interaction influences (see tables 3 and 4 for details on this). For example, for Encourage interactions this module computes the change on the values of the target's motivation and social attraction for the performer.

The change is computed using a non linear function with two arguments: the current value and the intensity of the change. Thus, the amount of the change depends on the distance of the current value to the neutral value (e.g. 0) as well as the intensity of the change. This is used to simulate the tendency of the values to stay on neutral levels. Thus, its harder to produce a change in the value from the neutral state than from its higher value (e.g. 100). The intensity is a value between 0 and 100 that corresponds to the strength of the interaction in the group, which reflects the sum of the group positions of its the performers.

Furthermore, if the revision process produces any change on the social relations then the members' group position is recalculated using the formula 1.

5.5 The Behaviour Module

The behaviour module manages the decisions concerning the character's actions. It consists in two different processes: one related to the character's task planning, and another that determines its reactions to the group interactions. These are regulated by the rules expressed on table 2.

First of all, the character will not necessarily engage often in the group interactions. This predisposition of interaction is computed using a probabilistic function that takes the character's motivation, group position and extraversion as arguments. A linear combination of the arguments determines a threshold that is checked using a randomized value. If this value is below the threshold then the character is motivated to act, otherwise it is not.

This function checked on regular intervals based update cycle of the mind, and whenever determines that the character is motivated to act the task planning process is started.

There are three possible outcomes from the planning process: (1) no suitable action is found; (2) an action to be performed the character; (3) an action to be performed by another character. In the second case the character proposes the action to the group, while in the third case the character will encourage the character that he believes that should perform the action.

The decision to perform or not the action that was proposed to the group is made according to the group positions of the members. Thus, opinions expressed by members with more influence in the group are taken more seriously in the decision. For example, if two members in the group express themselves against the action while just one agrees with it, this does not necessarily means that the action is not going to be executed. If the member that agreed with the action has a better position in the group than the other two together, then the character will feel supported and will probably execute the action.

The behaviour module also implements the rules for the reactions to the group interactions. For example, if the character is target of an Encourage interaction he may retribute the encouragement. In addition, if the character observes a Facilitate Problem or Obstruct Problem interaction he may decide to Encourage or Discourage the performer. These reactions, depend on the position and social relations maintained with the performer (see table 2).

6. EVALUATION

We have conducted an experiment with the Perfect Circle game, in order to evaluate the effects of the SGD Model on users that interact with groups of synthetic characters. Our goal was to test the hypothesis that groups of synthetic characters that interact following a similar dynamics as human groups do, will become more believable and consequently improve the user's interaction experience.

The experiment was conducted with 24 university students, 20 male and 4 female, using two main control conditions:

1. **Use of the SGD Model:** we built two different versions of the game: one where the characters followed the SGD Model and other where they did not. Thus, our first condition determines whether the subjects play with or without the believable group dynamics component. 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' group position, it was a simply majority rule.

2. **The Group Initial Structure:** subjects can start the game in a group with non neutral initial social relations of attraction and influence, which means that the initial group can have levels of cohesion. Such levels may be very high or very low. We have considered two different scenarios: one where the group has neutral social relations and another where the members of the group dislike each other, which, takes the group cohesion to very low levels. Note that this condition can only be applied when the game is run with the believable group dynamics component.

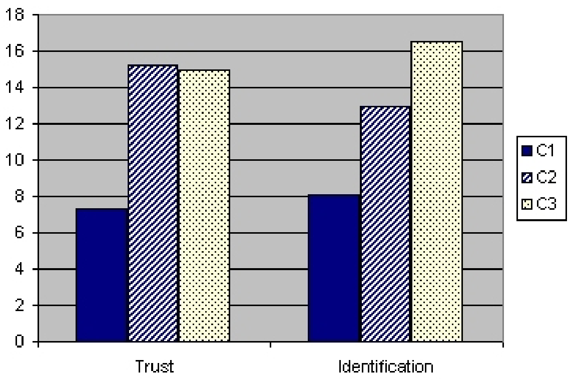

Figure 3: The questionnaire results.

Following the work of Allen et al.[2] we have decided to measure the users' interaction experience by measuring the users' trust and identification with the group. Allen et al. have conducted an experiment to measure the satisfaction of the members of a group that performed their tasks through computer-mediated interactions. They argue that, since trust and identification have a strong relationship with group satisfaction [10] [3], using their measures is a good approach to assess the group satisfaction.

Additionally they proposed two questionnaires: one to measure trust, with seven questions, and another to measure social identification, with five questions. We have adopted and slightly changed their questionnaires (removing one question for trust and adding one for identification), and used them to obtain our measures. We also added a free question to the end of our questionnaire where the subjects could write any desired comments.

During the experiment we divided the subjects into three different groups with 8 elements each. Each group played the game with a different condition: (C1) the first group played the game without the SGD Model; (C2) the second played with the SGD Model and with group at neutral cohesion levels; (C3) and the third played with the SGD Model but with the group at low levels of cohesion.

Subjects played the game for an hour and afterwards had half an hour to answer the questionnaire.

We have analyzed the questionnaire results using the Kruskal-Wallis nonparametric test [2] which computed the results shown in figure 3.

The chart on figure 3 shows a comparison of the group trust and group identification measured on the three control con-

[2]We chose to use nonparametric methods to analyze the data because they perform better with small size statistical samples.

ditions. As one can see, there is a clear difference on the levels of trust and identification observed on the subjects that played with the SGD Model and those who played without the SGD Model. Trust and identification were higher when the synthetic characters followed a believable group dynamics. There is also some difference between the identification of the subjects with the group on condition C2 and condition C3, which we believe is due to the fact that in the first case the group socio-emotional interactions were mostly positive, what may be less believable than a group where the socio-emotional interactions are both positive and negative, as the second case.

7. CONCLUSIONS

In this paper we have 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 in entertainment scenarios. To achieve such group believability we have proposed a model inspired by theories of group dynamics developed in human social psychological sciences. The dynamics of the model 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. The model was implemented in the synthetic characters that collaborate with the user within the context of a computer game (*Perfect Circle*). This game was used on an evaluation experiment which showed that if the synthetic characters follow a believable group dynamics the users' trust and identification with the group is found higher than without the model.

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