Building Believability in Groups of Synthetic Characters

Rui Prada, Ana Paiva

IST-Technical University of Lisbon and INESC-ID

Avenida Prof. Cavaco Silva - Taguspark

2780-990 Porto Salvo, Portugal

{rui.prada,ana.paiva}@gaips.inesc-id.pt

Abstract

Synthetic characters are used in virtual environments to improve the users' interaction experience. However, this effect is only possible if the characters are able to show a coherent and believable behaviour. Therefore, in scenarios where users and synthetic characters interact in the context of a group it is very important that the group interactions follow a believable group dynamics. In this paper we describe a model that supports the creation of believable group dynamics based on a characterization of the different types of interactions that may occur in a group. This model will be applied in the development of an application that will be used by a group of phsychologists in their studies of group dynamics.

1. Introduction

The use of Synthetic Characters in interactive virtual environments can greatly improve the user interaction with the environment and lead to more believable and real simulated environments. In particular, its application in interactive learning environments can foster the student's learning experience as shown by the results of Lester's work [14]. Furthermore, in virtual environments in general the presence of lifelike entities was identified by Bates [3] as one of the factors that can increase the sense of user presence and immersion. However this positive effect highly depends on the richness of the characters' actions and interactions, or, more concretely, on the characters' *believability*.

A *believable* character was defined by Bates [4] as a character that provides the illusion of life, and thus leads to the audience's suspension of disbelief. Furthermore, he also argued that the use of emotions is central in achieving such desired believability, which can only be achieved if the character is able to maintain a coher-

ent behaviour and personality that can meet the users' expectations.

Other results obtained by Reeves and Nass [21] show that people interactions with computers are fundamentally social. This work suggests that in order to meet the users' expectation, synthetic characters should be able to display coherent social behavious. This issue is in fact one of the main research areas of synthetic characters [9].

In some applications, such as for example entertainment [8] [23] or education and training synthetic characters "cohabit" with the user the same virtual environment. The user is often represented by an avatar, that acts on behalf of the user and following his/her commands. In these situations users and synthetic characters may engage in collaboration and behave as a group. This is the case of virtual communities such as the ActiveWorlds [12] and computer games like Role Playing Games (RPG) [1] in which players need to perform as a group in order to be able to reach their objectives.

Most of the research conducted on believability of synthetic characters is centered on interactions between the user and a single character [5]. Although some studies considered the interactions between several synthetic characters (see for example [23]) the presence of a human user as an active member of the group is not taken into account.

In the latter case we believe that is not enough for the characters to be believable as individuals, but we also need to consider the group as an identifiable entity and thus its own believability.

The goal of this paper is to show some ideias how to improve the believability of groups of synthetic char-

---

1 A role-playing game (RPG) is a game in which each participant assumes the role of a character (such as an ogre or a futuristic spaceship captain) that can interact within the game's imaginary world. Characters wander in the world looking for adventure and solving the game mysteries.

acters in order to achieve better interactions with the user. To achieve this believability we developed a model of interaction based on social and psychological theories of human group dynamics [2].

This paper is organised as follows: first we will give a brief description of the theoretical constructs needed for the development of the model, such as the notion of group and its relations. Then, we will describe believability in groups of synthetic characters, and the way group dynamics impacts on such believability. Finally we describe the architecture underlying the model and discuss its use for a future application.

2. Groups of Synthetic Characters

Virtual environments are becoming increasingly populated with synthetic characters that have active roles in such environments. This applies to several application domains, such as education [22] and entertainment [23] [17], and in particular in virtual communities, such as Active Worlds [12] or online Role Playing Games.

The problem is that usually the role of the synthetic characters in these communities is very restricted as they do not actively participate in the tasks that the user performs in the environment. It is true that they help the user in the environment but only perform secondary roles like a receptionist of a certain building, a shopkeeper, or simply a follower that the user controls as her/his will. Our goal is to enhance the role of these characters and make them be part of the team of the human controlled characters (the users' avatars). The synthetic characters should thus become active members in the group.

2.1. The characterization of our target groups

We focused our work on groups that involve a human user with several synthetic characters performing in a virtual environment where all the interactions must take place. We will consider groups with only a few members (small groups) and without a strong organizational structure. Thus, we are not concerned with groups as crowds or complex organizations and societies of agents.

The members of the group are committed to solve certain tasks in the virtual environment, which means that the group must interact and evolve in such a way that makes the resolution of those tasks possible.

Synthetic characters in these groups are autonomous agents that can engage into conversation using an agent communication language (ACL) and can manipulate objects in the virtual environment (e.g. get, give, use and drop items). The user is also represented as an agent (avatar) in the system that is not autonomous but controlled by the user.

The agents are expected to be socially autonomous as discussed by Castelfranchi [7] in the sense that they have autonomy on their goals and their believes. Nevertheless this autonomy is only partial and relative since the agents' performance is influenced by the other agents in the group and by the environment. Note that the performance can be influenced but never controlled, the agent will always make a decision based on its own goals and believes.

2.2. The definition of group

Several definitions for group have been proposed [11] [6] [19] but they frequently follow the restrictions of the context where they apply. Group definitions are in general based on the notions of *interaction, interdependency* and *mutual perception and identification*. A group can thus be seen as a set of entities that has the following set of properties:

- **Interaction:** The members of a group interact frequently.

- **Interdependency:** The members of a group have some interdependency, which means that one member's behaviour have affect on the other members.

- **Mutual perception and identification:** All members of a group have the perception of the group. They can identify the group, its members and recognize that they belong to the group themselves.

McGrath [19] in 1984 proposed a different definition inspired on the mathematical notion of fuzzy sets that defines a group in terms of degree of *groupness*. This definition is very flexible given that every collecton of people is a potential group. The degree of *groupness* is influenced by four factors: 1) the number of members in the group, 2) the level of interactions between the members, 3) the history of interactions and 4) the probability of future interactions of the group. The same approach is used in the notion of member of a group. Each individual can belong to several groups having for each a different degree of *belongingness*.

In our model, a group considers not only the three properties of *interaction, interdependency* and *mutual perception*, but also the notion of *groupness* and *belongingness*.

3. Believability of Synthetic Characters' Groups

How do we achieve believability in groups of synthetic characters? In general a synthetic character shows a believable behaviour if it has a positive effect on the interaction with the users. The same rule applies when we try to engage the user in a group of synthetic characters. However the fact that the character is believable as an individual is not by itself enough to assure the believability of the group. The synthetic character must also have a believable social behaviour when interacting with others, which in the case of our study implies a believable group dynamics.

With the goal of building a model for a believable group dynamics between the user and several synthetic characters we relied on theories of group dynamics developed in human social psychological sciences. According to Cartwright and Zander [6] since the first studies conducted by Lewin [15] [16] in his Field Theory, many different theories of group dynamics emerged following several different perspectives. We adopt the perspective followed by theories that Cartwright and Zander classified as *System and Interaction Theories*. These theories consider the group as a system of interacting members with observable inputs and outputs [2] [19] (see figure 1).
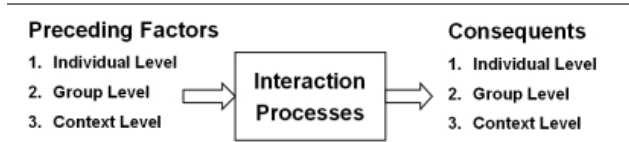

Preceding Factors
1. Individual Level
2. Group Level
3. Context Level

Interaction Processes

Consequents
1. Individual Level
2. Group Level
3. Context Level

Figure 1. The group process as a system of interacting members with observable inputs and outputs.

The observable inputs are also referred as *preceding factors* and are defined as variables that influence the interaction processes; they can be categorized in three different dimensions: the *individual level* related with the individual characteristics, the *group level* related with the group structure and the *context level* associated with the characterization of the environment and the nature of the task.

The observable outputs, also referred as the *consequents* of the group process, define the changes that the interaction processes cause on the situation that was initially verified. These changes occur on the same three different levels: the *individual level*, the *group level* and the *context level*.

The *interaction processes* are all the interactions and exchanges that occur between the members of the group.

The first studies on the interaction processes within a group are due to Bales [2]. He developed a method for group analysis based on the observation of the interactions that occur between the members of the group which he called the Interaction Process Analysis (IPA). Bales stated that a group in its process faces two different classes of problems: the *instrumental problems* which are related to the task, and the *socio-emotional problems* which are related to the social and emotional relations of the members. Furthermore, Bales divided the interactions concerning the task problems into *active* and *passive* interactions. Active interactions are those where the members give information while passive interactions are those where the members request information. The interactions concerning the socio-emotional problems can be positive or negative as they raise positive or negative socio-emotional responses on the members.

4. Modelling the Group Dynamics of Synthetic Characters

Our model of the group dynamics of synthetic characters consists in a characterization of the group process at four different levels: the characterization of the *context* that defines the environment and the tasks that the agents can perform; the characterization of the *group* that defines the group as an identifiable entity with its underlying structure; the characterization of the *individuals* that defines the individual characteristics of each group member such as their personality; and the characterization of the *interactions* that defines the different classes of interactions and their dynamics.

4.1. The Individual

The characterization of the individual in made at three different levels: the personal level, the group level and the social or relational level. The personal level defines the variables that describe the agent as a unique individual in the environment. It defines in addition to a unique identifier the agent abilities, personality and self-esteem.

1. **The agent abilities:** define the actions that the agent can perform in the environment; the set of abilities is important to determine the agent level of expertise in the group, which is an importan factor to define the agent position in the group.

2. **The agent personality:** we define the agent personality using two of the dimensions proposed in the Five Factor Model [18]: 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 related to the task resolution which is not our main focus.

   (a) *Extraversion:* is related to the dominant initiative of the agent. 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 favor.

3. **Self-esteem:** defines the confidence that the agent has on its own actions. Agents with higher self esteem will engage on more group interactions.

In the group level we define the agent expectations, motivation, position and degree of *belongingness*. The agent records this set of information for every group in which it is involved. This means that if an agent is involved in several different groups it has different expectations, motivation, position and degree of *belongingness* for each one.

1. **Expectations:** The agent expectations are a set of goals that it desires to be satisfied by means of the group interactions.

2. **Motivation:** The agent motivation defines the level of engagement of the agent in the group's interactions.

3. **Position:** The agent's position in a group defines its relative significance in the group, how important are the agent contributions for the group and how well are they accepted. The position is the result of the group common perception; one member only has a important position if the other members perceive it as such. The position is a result of the agent level of competence in the group and the social relations it maintains with the others.

4. **Degree of** *belongingness***:** this is a computed value based on the other three variables (expectations, motivation and position) that assesses the level of attachment of the agent to the group. Agents with high degree of *belongingness* are very tied to the group while agents with low degree of *belongingness* are not very attached and can easily leave the group.

The social level characterizes the information related to the other agents that the agent meets in the environment. It defines the social relations that the agent maintains and the knowledge that it builds about the others.

1. **Model of the other:** this model stores information about the other agents individual characterization, their abilities, self-esteem and personality, in addition to their information related to the group, such as their position and motivation.

2. **Social relations:** the agents build two different kinds of social relations, which are the support for the group structure (see section 4.2):

   (a) *Social attraction:* relations of attraction are related to like (positive attraction) and dislike (negative attraction) emotions. 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).

   (b) *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 [10].

4.2. The Group

In our model, a *group* is defined as a set of individuals that follow the definition presented in section 4.1. However, more than just a set, the group is a unique and identifiable entity with an underlying structure. The group also keeps a record of its history of events and has a degree of *groupness* associated.

1. **The group identity:** identification is one important factor in the definition of a group. For that reason we use a unique name to allow the group to be clearly distinct in the environment and enable the agents to recognize the group 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 be excluded.

3. **The structure:** the group structure is defined in different dimensions. According to Jesuino [13] the most common are the structure of communication, the structure of power and the structure

of interpersonal attraction (sociometric structure [20]). As we are handling small groups the structure of communication should not be complex and we decided not to included it in our model. The group structure is then defined in two dimensions: the *structure of power* that is defined by the group members' social influence relations, and the *sociometric structure* that is defined by the members' social attraction relations (see section 4.1).

4. **The history:** the group records some events such as the group creation and the admission and exclusion of members. This also include the history of the interactions that are relevant for the group, like for example the tasks that the group have undertaken.

5. **The degree of** *groupness***:** assess the group level of cohesion. This is a computed value based on the composition, structure and history of the group.

4.3. The Interactions

This section describes our concept of interaction and presents a classification for the different types of interactions among elements of groups. It also defines the interaction dynamics based on the classification proposed.

An interaction is related to the agents' execution of actions. In fact one interaction occurs when an agent executes actions that can be perceived and evaluated by the others. Each interaction has a certain strength in the group that defines its relative importance in the group process. Also in addition to the agent responsible for the interaction each interaction has a set of agents that support the interaction. For example considering the case where an agent presents a new idea to the group, the set of supporters will be the set of agents that agree with that idea. The strength of an interaction is directly related to the position that the agents that support the interaction have in the group.

To summarize an interaction is defined by an *action* or pattern of *actions*, the *agent* that performed the action, its *strength* in the group, and a set of *supporters*.

In order to model the dynamics of the group process we have characterized the type of interactions that may occur in the group. Although the interaction is closely related to the action that the agent performed, its classification is more than just the classification of the action itself. It depends on the action's results, the context of the execution, and also the agents' perception. Indeed the classification of an interaction is made at the individual level and therefore is dependent on the perspective of the individual that classifies it. E.g.

the same action can be perceived to be positive to the group by one agent but negative in the view of another.

Our classification was based on the categories that Bales proposed on his IPA system [2]. We follow the same main distinction of socio-emotional and instrumental interactions, and divide the socio-emotional interactions into positive and negative, and the instrumental interactions into active and passive (see figure 2).
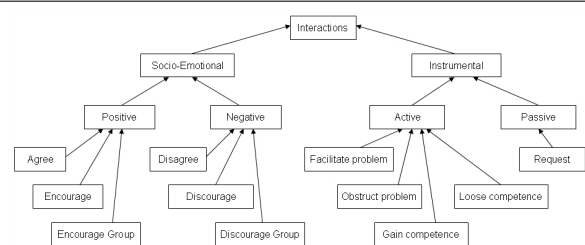

Figure 2. The classification of the interactions.

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 oppose by symmetry (*disagree, discourage and discourage group*).

- Positive socio-emotional interactions
    1. **Agree:** This class of interactions show the support and agreement of one agent towards one of the interactions of another agent consequently raising the importance of that interaction in the group.
    2. **Encourage:** These interactions represent one agent efforts to encourage another agent consequently facilitation its social condition (e.g. increasing motivation and self-esteem).
    3. **Encourage Group:** This class of interactions are similar to those on the *Encourage* category but apply to a group of agents. These interactions encourage the group and facilitate the group social structure (e.g. degree of groupness).
- Negative socio-emotional interactions
    1. **Disagree:** This class of interactions show disagreement of one agent towards one of the interactions of another agent consequently decreasing the importance of that interaction in the group.

2. **Discourage:** These interactions represent one agent hostility towards another agent and its efftors to discourage it.

3. **Discourage Group:** This class of interactions are similar to those on the *discourage* category but apply to a group of agents. These interactions discourage the group and raise the entropy of its social structure (e.g. lower its degree of groupness).

The categories proposed by Bales at the instrumental level are focused mainly on speech acts. And in addition there is not a clear connection between the instrumental interactions an the task itself.

In the context of virtual environments interactions that are not based on speech acts are very important, take for example object manipulation actions. 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 active instrumental interactions (*faciliate problem, obstruct problem, gain competence, and loose competence*) and one generic passive instrumental interaction (*request*) that do not have a direct correspondence in the IPA instrumental categories.

- Active instrumental interactions

  1. **Facilitate Problem:** This class of interactions represent the interactions made by one agent that solve one of the group problems or ease its resolution.

  2. **Obstruct Problem:** This class of interactions represent the interactions made by one agent that complicate one of the group problems or make its resolution impossible.

  3. **Gain Competence:** This interactions make one agent more capable of solving one problem. This includes for example the learning of new capabilities, or the acquisition of information and resources.

  4. **Loose Competence:** This interactions make one agent less capable of solving one problem. For example by forgetting information or loosing the control of resources.

- Passive interactions

  1. **Request:** Using these interactions one agent requests the help of the others. For example it advertises a problem that it believes that should be solved, or it requests some information, or ask for an opinion.

4.4. The interactions' dynamics

4.4.1. The interactions' observable outputs

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 of the group variables (e.g. the group sociometric structure) and depend on the strength of the interaction in the group. To simplify our model we consider only changes in four of these variables as the main consequences of the group process: the *social attraction* and the *social influence* relations, the *self-esteem* and the *motivation* of individual members.

The social attraction changes are associated with the occurrence of socio-emotional interactions. An agent changes its attraction relation with another agent positively if it is target of positive socio-emotional interactions by that agent and negatively otherwise.

Social influence is interrelated with social power which is classified into five different types according to French and Raven [10]: *reward power, coercive power, legitimate power, referent power* and *expert and information power*. Given the characterization of our target group (e.g. it does not have a strong organizational structure) we only consider the influence caused by the expert and information power. Expert and information power is the power that a person P can exert over a person R sustained on the difference between their competences and the access that they have to certain information.

This fact suggests that the changes in the social influence relations are associated with the instrumental interactions. One agent gains influence over the others when it is able to demonstrate expertise or obtain resources that are useful to the resolution of the group's tasks. In other words when the agent performs one interaction classified as *facilitate problem* or *gain competence*.

The agent only gains influence over the agents that are committed and support the tasks involved in the interactions. For example in a group with three agents A, B and C if agent A suggests a task that only A and B agree the social influence relations with agent C do not change if agent B is able to solve the suggested task, it will only gain influence over agent A.

The interactions classified as *obstruct problem* or *loose competence* have the opposite effect to the one described above. The agent responsible for the interactions will not gain but loose influence in the group.

Motivation and self-esteem change positively when the agent is the target of positive socio-emotional in-

teractions or is responsible for *facilitate problem* and *gain competence* interactions. On the other hand if the agent is responsible for *obstruct problem* and *loose competence* interactions or is the target of negative socio-emotional interactions its motivation and self-esteem will decrease.

4.4.2. The interactions' observable inputs

We have just discussed how the occurence of each type of interaction affects the main variables of our model and will now discuss the problem in the other way around, how do the group variables influence the occurence of the interactions.

Motivation and self-esteem are two of the important variables that drive the agent tendency to initiate interactions. Highly motivated and self-confident agents will engage in more interactions within the group. If the levels of self-esteem and motivation are low the agent might not interact at all.

The agent's personality also defines some of the agent tendencies for action. Agents with high levels of *agreeableness* will engage more frequently in positive socio-emotional interactions while agents with low *agreeableness* with favor the negative socio-emotional interactions. The *extraversion* influences the frequency of interaction in general. Agents with high levels of *extraversion* engage in more interactions than agents with low *extraversion* values.

The frequency of interaction also changes according to the position that each member hold in the group. Agents with a better position in the group (e.g. more influent members or with better and more appropriate skills to handle the group current tasks) contribute with more interactions.

The social relations that agents build during the group process are a key factor in the decision on the type of interaction that the agents will follow.

Agents engage in positive socio-emotional interactions with other agents if they have a high attraction for them or if the social influence that the agent suffers is considerably high. On the other hand agents engage in negative socio-emotional interactions when the social influence and the attraction levels are low.

Considering the instrumental interactions, agents engage in positive instrumental interactions whether the problem that they target is one of the agent's current goals or if they have a high attraction or suffer from the social influence of the agents that are committed with the problem.

4.5. The Context

The context defines the environment where the agents perform and the type of tasks that can be un-

dertaken. One of the important definitions in the context is the type of actions that the agents can perform and their potential classification according to this model (see section 4.3). The context can also defined some social norms that may drive the interaction process.

5. The Agent Architecture for a Synthetic Group Member

We build our agents using a simple architecture that follows an ordinary pipeline with three steps. First the agent perceives the world, and then using the perceptions' information it updates its knowledge base that is used subsequently to decide the next action to take.

To integrate our group dynamics model into the architecture we have included a component that uses the information from the perceptions and the knowledge base to build a group dynamics model that will influence the agent's decision process.

The group dynamics model component is divided in three different processes (see figure 3):

1. **Interaction Identification:** Using the information from the perceptions and the knowledge base, this process try to match the current course of actions into a known class of interaction. The interaction must be coherent with the believes on the current group model.

2. **Reaction:** If a new interaction is perceived this process updates the group model with the appropriate reactions (see section 4.4.1). For example it lowers the attraction for an agent that has just discourage our participation.

3. **Decision Influence:** The active interactions and the believes about the group state will influence the decision on the next action to take (see section 4.4.2). This process uses this information to activate and weight the actions to be considered in the decision procedure.
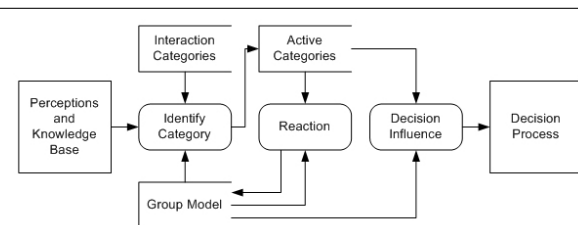

Figure 3. The Group Dynamics.

6. Conclusions

In this paper we have discussed the problem of the believability of synthetic characters when interacting in group, emphasizing the importance of such believability when the synthetic characters engage in a group with characters that are controlled by the user.

We have presented a model that we believe will support the creation of believable group dynamics based on a characterization of the different types of group interactions and discuss an agent architecture that integrates this model.

The model will support the creation of an application to be used by a group of phychologists in their studies of group dynamics. The application will immerse a user in a virtual environment with several synthetic characters that should behave as a working group in order to solve simple tasks in a virtual environment. The user is then placed in several different scenarios, for example in conflict situations, in order to evaluate its performance in the group. This simulates an evaluation method that is often used by psychologists. The classic method uses several people as actors to create the scenario. However, it is often not easy to have the human resources available to produce such evaluations. The use of this new application will make it possible to construct the evaluation scenarios even without many human resources as we substitute the group members that are not being evaluated with synthetic characters. This application will make a great test case to evaluate the effects of our model in the believability of synthetic characters' groups. We expect to compare the results of using our model of group dynamics with the situation of not using a model at all.

7. Acknowledgements

References

[1] S. Acton. Great ideas in personality website. http://galton.psych.nwu.edu/bigfive.html, 2004.

[2] R. F. Bales. *Interaction Process Analysis*. The University of Chicago Press, Chicago, 1950.

[3] J. Bates. Virtual reality, art and entertainment. *Presence: Teleoperators and Virtual Environments*, 1992.

[4] J. Bates. The role of emotions in believable characters. *Communications of the ACM*, 37(7):122–125, 1994.

[5] T. Bickmore and J. Cassell. Relational agents: A model and implementation of building user trust. In *Proceedings of the CHI'01 Conference*, Seattle, USA, 2001.

[6] D. Cartwright and A. Zander. *Group Dynamics: Research and Theory*. Harper and Row, New York, 1968.

[7] C. Castelfranchi. Garanties for autonomy in congnitive agent architecture. In *Intelligent Agents: ECAI-94 workshop on Agent Theories, Architectures, and languages*, pages 56–70, The Netherlands, August, 1994. Springer Verlag.

[8] M. Cavazza, F. Charles, and S. J. Mead. Agents' interaction in virtual storytelling. *Lecture Notes in Computer Science*, 2190, 2001.

[9] K. Dautenhahn, A. H. Bond, L. Cañamero, and B. Edmonds. *Socially Intelligent Agents: Creating Relationships with Computers and Robots*. Kluwer Academic Publishers, 2002.

[10] J. R. P. French and B. Raven. *Group Dynamics: Research and Theory*, chapter Bases of Social Power. Harper and Row, New York, 1968.

[11] A. Hare. *Handbook of Small Group Research*. Free Press, New York, 1976.

[12] http://www.activeworlds.com. The activeworlds website, 2004.

[13] J. C. Jesuíno. *Psicologia Social*, chapter Estrutura e processos de grupo: interacções e factores de eficácia. Fundação Calouste Gulbenkian, 2000.

[14] J. Lester, S. Converse, S. Kahler, S. Barlow, B. Stone, and R. Bhoga. The persona effect: Affective impact of animated pedagogical agents. In *Proceedings of Conference on Human Factors in Computing Systems (CHI'97)*. ACM Press, 1997.

[15] K. Lewin. Field theory and experiment in social psychology: Concepts and methods. *American Journal of Sociology*, 44:868–897, 1939.

[16] K. Lewin and D. Cartwright. *Field Theory in Social Science*. Harper and Row, New York, 1951.

[17] S. Marsella, W. L. Johnson, and C. LaBore. Interactive pedagogical drama. In *Proceedings the 4th International Conference on Autonomous Agents*, Montreal Canada, 2000. Springer.

[18] 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.

[19] J. E. McGrath. *Groups: Interaction and performance*. Prentice Hall, New Jersey, 1984.

[20] J. L. Moreno. *Who Shall Survive?* Nervous and Mental Disease Publishing Co., Washington D.C., 1934.

[21] B. Reeves and C. Nass. *The Media Equation. How People Treat Computers, Television, and New Media Like Real People and Places.* Cambridge University Press, 1998.

[22] J. Rickel and L. Johnson. Virtual human for team training in virtual reality. In *Proceeedings of AIED'99 - Ninth World Conference on AI in Education*, 1999.

[23] B. Tomlinson and B. Blumberg. Social synthetic characters. *Computer Graphics*, 26(2), May 2002.