Revista EDaPECi

Educação a Distância e Práticas Educativas Comunicacionais e Interculturais

ISSN 2176-171X

Improving the believability in the interaction of synthetic virtual agents: Towards Personality in Group Dynamics

Maria Augusta S. N. Nunes - gutanunes@dcomp.ufs.br*
Danilo Reinert - dreinert@dcomp.ufs.br*
Rui Prada - rui.prada@gaips.inesc-id.pt **
Jonas S. Bezerra - jonassantosbezerra@gmail.com*
João Camilo - joao.camilo@ist.utl.pt**

*Universidade Federal de Sergipe/DECOMP (Sergipe/Brasil)
** INESC-ID and IST-UTL (Porto Salvo/Portugal)

Resumo

The interaction among humans and virtual agents should be provided for users like an experience as natural as possible. Considering the same perspective of interaction found in humans, researchers define Personality as a key role for believable interface in group dynamics. In this paper, we describe how much Personality is fundamental to generate individuality in humans, and so, in virtual agents. By integrating those concepts in social agents we intend to conquer more believability during its interactions in groups of simulated societies. This paper presents a computational model that support the creation of group dynamics in teams of virtual agents that are engaged in cooperative tasks in order to create believability. Then, we describe an ongoing experiment based on a database of real agent

KEYWORDS: Affective Computing, Personality, Social interaction in Lifelike Virtual Agents, Group dynamics.

1. INTRODUCTION

In nature, there are many animals' species that have certain traits in common. Populations of those different animals, instinctively, interact with each other, and together, those populations form communities. Thus, considering that the human society also comes from the animal species, they also, instinctively, come together and form groups as well as in many other species.

According to Wikipedia (2010) a social group is defined as "a collection of humans who share certain characteristics, interact with one another, accept expectations and obligations as members of the group, and share a common identity".

ISSN 2176-171X

Note that people are, inherently, social creatures and so, they are constantly searching for other people all life long creating groups in order to: share their interest, solve their problems, have a date, meet people, have an informal conversation, build political party, collaborate in some issue, as well as other interests.

Usually a group is conceived taking into consideration the members' interests and objectives. Normally, the structure of a group can be characterized in terms of member's interpersonal relations (COLLINS, 1969). Interpersonal relations between group members define member's position in a group. Older members, considering their position on the group, decide the belonging of a new member in a group as well his permanence in it. The member's position in the group is highly influenced by users Personality.

Theories of interpersonal attraction can predict the way human Personalities interact among them. Studies carried out by (NASS et al, 1995), have indicated a deep psychological literature, which indicates strong relationship between similarity and attraction. That means people prefer to interact with others (strangers or not) who have similar Personality rather than with others who have Personalities that are different from their own (NASS and LEE, 2000). Thus, issues of social power, influence, and interpersonal conflicts definitively affect group dynamics and performance, as described in (PRADA and PAIVA, 2009).

In the last years, scientists like (DAMASIO, 1994) are proving how psychological issues influence the human decision-making process. Considering that, Affective Computing scientists have tried to dock them in order to support the computational decision-making process. Note that the Affective Computing scientists are not just interested in provide human abilities, like Personality and Emotions, to computers to improve their interface, instead of it, they are enabling computers to better recognize those human aspects in order to, more importantly, improve the interaction between human and computers (PICARD, 1997).

Indeed, Affective Computing scientists have started to consider the Personality theory (and other Social-emotional theories) (NUNES, 2009b) in the computational decision-making process towards to improve the powerful and efficiency of the interaction of the virtual agents in lifelike social environments. Specially, in the context

ISSN 2176-171X

of believable lifelike agents, Affective Computing scientists have proved that Personality may be the driving force to generate believable lifelike agents in the group dynamics leading users to the suspension of disbelief (PRADA, CAMILO and NUNES, 2010). They highlights that Personality directs the goals of each social agent becoming unique and consequently its behavior maintains some coherence in the group dynamics.

In this paper, we describe, partially, the computational model created by Prada in (PRADA and PAIVA, 2005). It supports the creation of group dynamics in teams of virtual agents that are engaged in cooperative tasks in order to create believability during the group interaction towards to the resolution of problems. This model is called Synthetic Group Dynamics (SGD model). We also define Personality considering aspects of Personality theory. Next, we describe the Psychological approach used by SGD model in order to represent Personality and how it improves the agents' interaction providing the suspension of disbelief. We also present the approach used by us to extract Personality from humans in order to use those data in virtual agents of SGD model. Then, we present a *case study* that describes how we are using those extracted Real human personalities to give indices that SGD model provides an efficient interaction among virtual agents improving the believability in the group dynamics and by consequence in the Human Computer Interface.

2. SYNTHETIC GROUP DYNAMICS (SGD) MODEL

The SGD model (Synthetic Group Dynamics) (PRADA and PAIVA, 2009) uses a metaphorical human-like model of Personality in order to create individuality and coherence in synthetic agents that interact in virtual teams with the purpose of increasing the believability in the group dynamics.

The SGD Model was built on the principle that each member of some group should be aware of the other group members' and the group itself. In addition, it should be able to build its proper knowledge regarding the group's social structure and to use this knowledge to drive its behavior.

In concrete terms, the SGD Model was created in order to model the perception, knowledge building, behavior and action processes of each Real/Virtual agent collaborating as a group in a Virtual Environment. The SGD Model in the mind of each

ISSN 2176-171X

agent is presented in figure 1 and their components in figure 2.

Note that in this paper we decide to present only the *Knowledge base* because it is the main component in order to generate the group dynamics where features of Agent's Personality appear.

The agent's group dynamics is modeled in agents mind in *Knowledge base*, as you see in figure 2.

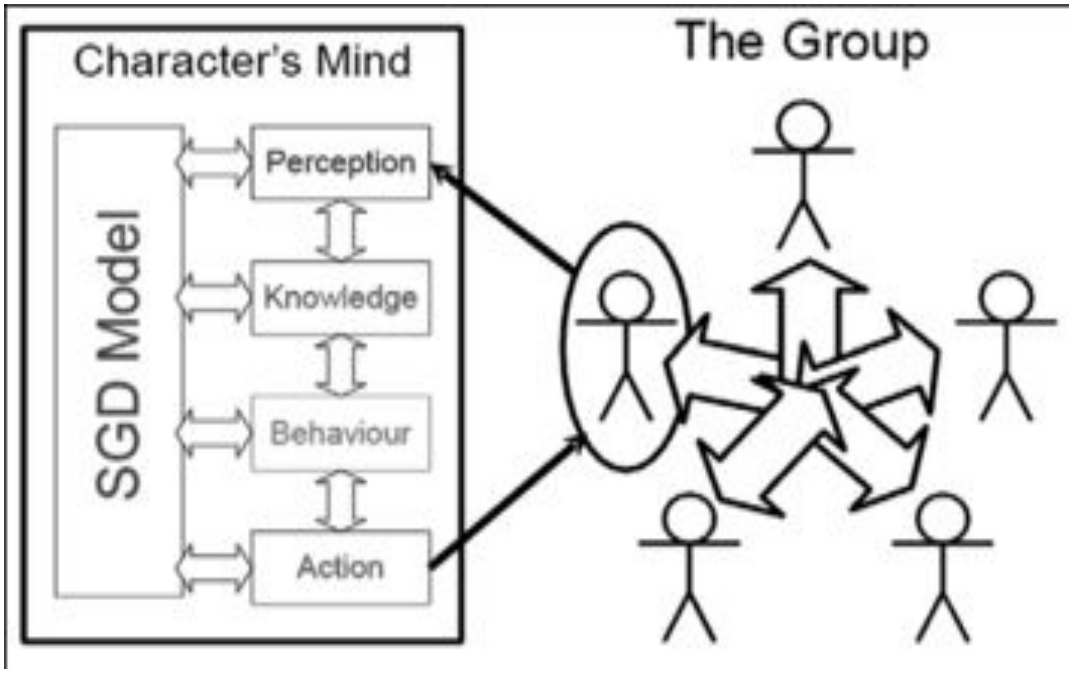

Figure 1. The SGD model in the mind of each member of the group

The *Knowledge base* is characterized by four different levels: (i) *the individual level*: defines how individual characteristics of agents influence their behavior in the group. Agents' skills and personality have an important role here; (ii) *the group level*: defines how the group's structure influences agents' behavior. The social relations play an important role at this level; (iii) *the context level*: defines how social norms, culture and the nature of the task influence the agents' behavior; (iv) *the interactions level*: defines the type of interactions that occur in the group. This classification has a central role in the model, because the group dynamics is defined around the occurrence of interactions.

ISSN 2176-171X

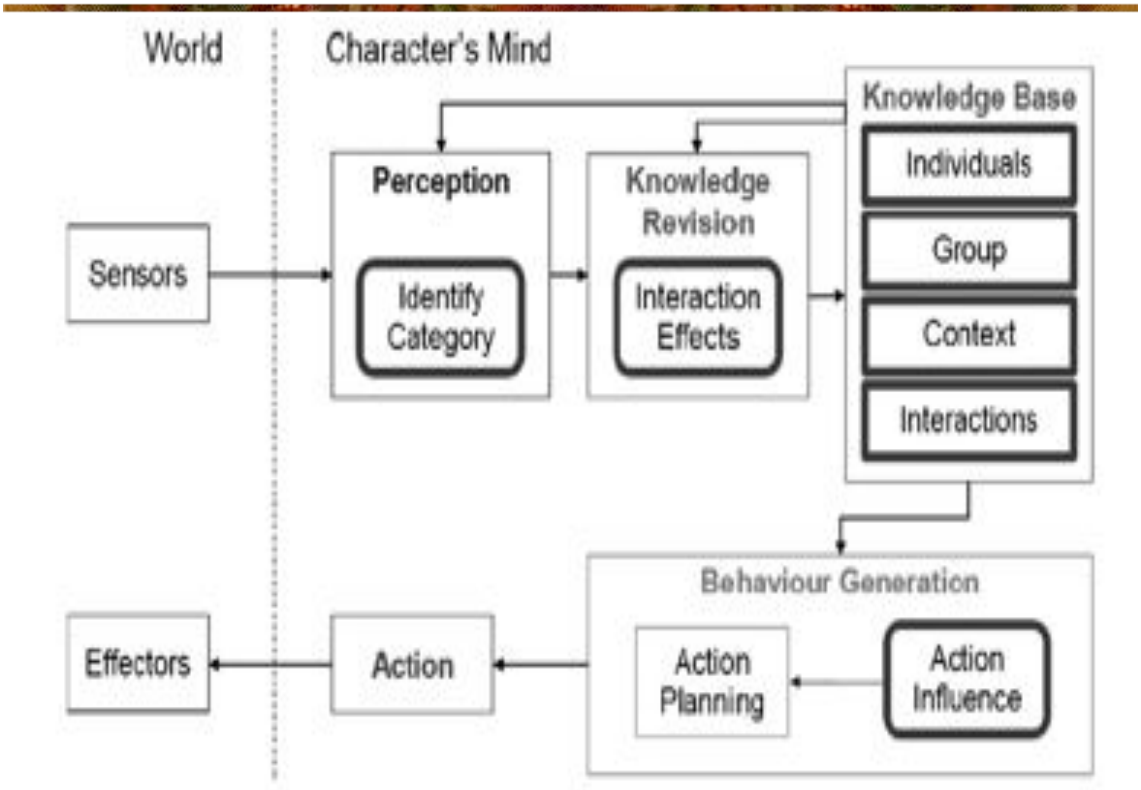

Figure 2. The agent's mind components of SGD

Agents maintain knowledge on all these four levels of their *knowledge base*. At the individual level they store knowledge about the abilities that every member of the group has (including the self). These are actions that are relevant to the solution of the task and their proficiency level. In addition, agents store knowledge regarding the members' personality.

At the group level the social relations are defined in two different dimensions: (i) relations of social attraction that define the interpersonal attraction of the members in terms of like and dislike attitudes, and (ii) relations of social influence that define relations of social power.

At the interactions level agents store knowledge regarding the interactions that occur in the group considering the group dynamics, as presented in figure 3 (PRADA and PAIVA, 2009).

An interaction is defined as a set of events that occur in a given situation. Interactions are divided into two main categories depending on if they are related to the task (instrumental) or related to socio-emotional issues (FRENCH and RAVEN, 1968).

ISSN 2176-171X

The SGD model implements behavior patterns, inspired by results from social sciences, it allow agents to generate "human-like" group dynamics. Considering that, Personality and Socio-Emotional aspects are very important to create believability in a group dynamics. In this paper we are specially focused on the Personality.

Next we present the description of Personality followed by the theory adopted to represent Personality in the SGD Model.

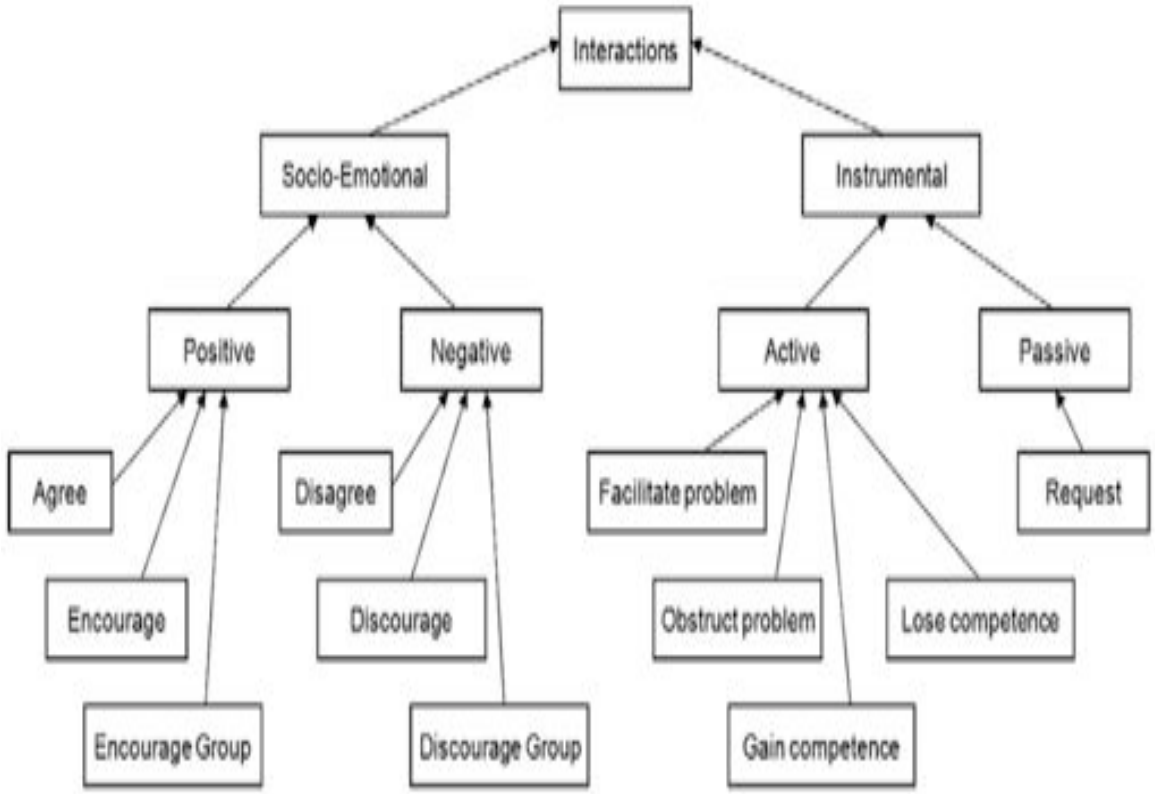

Figure 3. Categories of interactions

3. PERSONALITY

Personality is more than just superficial physical appearance. Personality is relatively stable and predictable. However personality is not rigid and unchanging, it is normally kept stable over a 45-year period that begins in young adulthood (SOLDZ and VAILLANT, 1998).

Personality can psychologically differentiate people. We found evidences that personality is the key role to create diversity in a group and beneficiate the group dynamic (NASS et al, 1995).

ISSN 2176-171X

3.1. Historical view

There are many different theories that try to model people's personality. Nevertheless, it is broadly accepted that personality is stable over time, even though it can change in result of significant events in people's life. Most of these theories try to categorize people in types or define certain dimensions to fit people's particular patterns of behaviors.

Some examples are: Eysenck's two-dimension model that define personality in the dimensions of Extraversion and Stability; Cloninger's Temperament Theory; Myer-Briggs core types based on Jungs' psychological types or Catell model that used 16 different trait descriptors to rate behavior of groups of people. Essentially, among all these theories, in order to simplify and organize the Traits, researchers created the Big Five/Five Factor Model of personality (DIGMAN, 1990). It is one of the most popular.

The formal beginning of the Big Five (JOHN and SRIVASTAVA, 1999)/FFM (Five Factor Model) (MCRAE and JOHN, 1992) was proposed by Fiske, replicated by Norman and derived from Cattel's natural language Traits. They were composed by 5 dimensions, are labeled as: (i) Extraversion, (ii) Agreeableness, (iii) Conscientiousness, (iv) Neuroticism, (v) Openness to Experience. They are briefly described as: (i) Extraversion implies an energetic approach toward the social and material world and includes traits such as sociability, activity, assertiveness, and positive emotionality; (ii) Agreeableness contrasts a pro social and communal orientation towards others with antagonism and includes traits such as altruism, tender mindedness, trust, and modesty; (iii) Conscientiousness describes socially prescribed impulse control that facilitates task and goal-directed behavior, such as thinking before acting, delaying gratification, following norms and rules, and planning, organizing, and prioritizing tasks; (iv) Neuroticism contrasts emotional stability and even temperedness with negative emotionality, such as feeling anxious, nervous, sad, and tense; (v) Openness to Experience describes the breadth, depth, originality, and complexity of an individual's mental and experiential life.

3.2. Personality in the SGD model

Loyall (1997) defines believable agents as personality-rich autonomous agents with powerful properties of characters from the arts. Based on an analysis made by him in artists and his own experience, he built a unique set of requirements for autonomous believable agents, which includes personality, emotion, social relationships, self-motivation and goal, and others. Observing these requirements' descriptions we may notice that many of them are related to Personality, turning it one of the most important requirement for believable agents.

Based on this study, Prada developed the SGD Model considering Personality as a fundamental factor in the complete agents' model. Mentioning the Extended SGD Model1 (MA, 2009), Personality plays a wide role in the model; it characterizes behaviors, motivations, and thoughts, defining what and how agents do something.

Next, we, briefly, describe a case study where Prada applied the extended SGD Model. Indeed, we present how we are doing the extra experiment in order to validate the SGD model by using a database of Real People.

4. CASE STUDY

In the case study, the extended SGD Model was used in the mind of each society's agent. The mind of each agent was presented in section 2. Each agent acts as lifelike characters in an adapted version of the game "Perfect Circle: the Quest for the Rainbow Pearl", presented in (PRADA and PAIVA, 2005).

4.1. Perfect circle: a brief description

The game takes the user into a fantasy world where the gods have been banned to imprisonment into the essence of gemstones, which have been shattered and scattered throughout the diverse world planes. The tales of the god's imprisonment are ancient and were completely unnoticed to men for many generations, until the finding of the sacred writings. Since then, several men, known as the Alchemists, have dedicated their

[1] The Extended SGD Model is an extension of the original SGD Model developed by Prada (PRADA and PAIVA, 2009).

lives to the study of gemstones and their secret powers. However the writings' are incomplete and reveal just a small part of the story. From time to time Alchemists are organized in groups (5 agents) and they depart searching the world for further clues that may help to complete the missing pieces of the story (to see more in (PRADA and PAIVA, 2009)).

Note that, actually, in the game, four Alchemists are personified by Synthetic Virtual Agents and, the fifth (last one), is represented by the external user, personified by the Real People/Agent.

In the game, goals are driven to the whole group. Group members should autonomously interact to each other in order to create group dynamics reaching all goals until the game finish. Sometimes, group members are considered to have individual goals, which is to become richer than others in the game. So as to reach the individual goals, agents may perform particular actions, even if sometimes the agents perform a selfish action (not related to the group's main goal). Each action is based on an individual planning created by each agent. The individual planning are strategic steps used by an agent in order to reach a goal. When the agent is motivated to act in the game it may suggest those future actions to others members. The suggestion is analyzed by each member of the group. Each member gives its agreement or disagreement considering who may effectively help the agent to perform the task. Agents have some abilities used to solve problems/tasks in the game. During the game those agents may improve its experience in solve those particular tasks, becoming more proficient in it.

4.2. The evolution of SGD model and Perfect Circle

The first version of SGD Model (PRADA and PAIVA, 2005) and (PRADA and PAIVA, 2009) defined personality as an important factor in the group dynamics. However it used a simple version of the Five Factor Model of Personality based only on two factors. Moreover, the factors were not explored in their full extend. Then, an extension for the SGD Model, which includes all five factors of the FFM, was proposed, projected and implemented (PRADA, MA and NUNES, 2009). This extension has brought more complexity and robustness to the model by dealing with all five factors of the FFM, increasing, thus, its believability. A new version of the game "Perfect Circle"

ISSN 2176-171X

was developed, it includes the updated version of SGD Model (MA, 2009).

4.3. How personality influences in the game?

The personality influences agents' behavior, motivation and its reactions in the game. Each agent in the game has a unique Personality composed by the five factors of FFM. Each factor influences, differently, the agent behavior in the game. It may stimulate or inhibit the agent interaction.

As stated in topic 2, at the SGD Model, an interaction is defined as a set of events (or pattern of actions) that occur in a given situation. Interactions have a set of performers (agents that are responsible for the actions), a set of targets (agents that directly suffer/benefit from the effects of the interaction) and a set of supporters (agents that support the interaction, e.g., agree with it, but are not directly involved in the executions of actions).

In the Table 4.1 we show you on which interactions each one of the five factors of Big Five exerts influence.

The Table 4.1 is an example of how the Personality affects the agent's behavior. Note that there are also many other important effects like in agents' motivations creating the individuality in the behavior of each character. For detailed information please look at (MA, 2009) and (PRADA, CAMILO and NUNES, 2010).

4.4. Introducing an experiment

We are using a tool specifically developed to perform simulations and evaluate results of the new version of the Perfect Circle game (MA, 2009) (called PCeval).

These simulations are conducted with groups of five agents, each agent has a pre-defined Personality. As already proved at (MA, 2009), the implementation of the extended SGD Model in the game is working consistently. Then we have a solid basis to perform various experiments, and thus, analyze their results.

In order to clarify what kind of results we will obtain from those simulations, let's take a look at some of the data returned from a simulation's evaluation. We must be aware about the logs generated while a simulation is running. These logs contain information about the interactions and states of the group and each character (virtual

ISSN 2176-171X

agents) in the game simulation.

	Group position	Extraversion	Agreeableness	Conscientiousness	Neuroticism	Openness
Encourage	X	X	X			
Discourage	X	X			X	X
Agree	X	X	X			
Disagree	X	X			X	X
Group instrumental	X	X	X	X		
Individual instrumental	X	X		X		X
Action execution effort	X	X		X		

Table 4.1. Influence of variables (group position and personality) for each interaction

The tool PCeval (MA, 2009) is a Java application that analyzes the logs of a simulation and creates CSV files with data organized in tables for better interpretation. These files bring us information about the group as a whole and each character (virtual agent) in the group.

In relation to the group, the returned data, stored in the log, are: Time that last the simulation, Numbers of Proposals in the simulation, Numbers of Actions in the simulation.

In relation to the characters, the returned data, stored in the log, are: Influence at each other member of the group, Attraction for each other member of the group, Group Position for each other member of the group – these three variables compose the social relations of the character -, and Motivation of the character at the game's end. It's also generated a data that calculates the performance of the group at the end of simulation. This performance is given by the formulae:

Performance = (3600 / Time) + 5 * (Actions / Proposals)

With those data we may draw conclusions about the effectiveness of groups dynamics considering many already matched Personalities. We intend to establish

ISSN 2176-171X

logical criteria for group formation and then, again, do simulations with those groups. At the end of the simulations, we will evaluate the relationship between the performance of the groups and their participants. We expect to find interesting information about the influence of each Personality' FFM has on groups' interactions, and perhaps even suggest valid criteria for forming groups for a particular purpose.

5. AN EXPERIMENT BASED ON REAL PEOPLE PERSONALITY

Here, in this paper, we briefly describe an extra ongoing experiment based on the results of the SGD model proposed in the (PRADA, MA and NUNES, 2009). In our extra experiment we are using only the Human/People Real Personality in order to personify each agent (Alchemist) of the "Perfect Circle" game.

5.1 How we got the personality of real people?

In order to get the Personality of Real People to personify the Alchemists we used a Database from a work done by John Johnson (2005). From August 1999 to May 2001, John Jonson made available online his well-developed and well-validated Personality Traits Inventory called NEO-IPIP Inventory (JOHNSON, 2000). 175000 people answered his online NEO-IPIP questionnaire. Then, 21588 answered questionnaires were selected as valid protocols [10]. Such data were used for determining high, average or low scores on the BigFive/FFM factors. Thus, those 21588 answers became the potential Personality database that we are going to use to define the Alchemists' Personality in the "Perfect Circle" game.

5.2. How we are using the real personality in "Perfect Circle" game?

We are going to use the Personality database as a default Personality for each of those 5 Alchemists on the "Perfect Circle" game.

In order to create believability and the efficiency in the group dynamics we created a new database based on Johnson's Personality database. We extracted the first 7000 valid protocols from those 21588 protocols selected by Johnson (2001). From those 7000 Personality database we apply a Recommender System modeled (NUNES, CERRI and BLANC, 2008) and developed by Nunes (2009a).

ISSN 2176-171X

This Recommender System was based on similarity of Personality Traits. It means, the first recommendation was done based on similarity on the Five Factors of Personality considering the Big Five factors. Thus, we recommended the first 500 more similar Real people Personality putting them into groups (Alchemists' groups). Each group was composed by 5 more similar members (considering Personality Traits). Each member was represented by one Alchemist. Thus we create 100 groups of 5 Alchemists each. Each Alchemist has the more similar Personality Traits possible considering the details of the Recommender System (NUNES, 2009a).

We also decide to create a second database, called control group. From that, we got those 7000 valid protocols and selected randomly 100 groups with 5 members each. Our Recommender Systems this time searched the members randomly, that means, neither based on similarities nor based on complementarities. The Recommender just got randomly 100 groups with 5 members each.

5.3. Partial conclusions

The real personalities data will be used as default Personalities for each of the virtual agent of the "Perfect Circle" game. The "Perfect Circle" game, as described before, will be simulated hundreds of times considering the recommendations done by the Recommender System (NUNES, 2009a).

The first recommendation was based on similarity and the second one, the control group, was randomly created. We intend to use the real agents Personality in the Alchemists instead of the virtual (randomly created by Prada for his experiment (PRADA and PAIVA, 2005)). We intend to observe how the Alchemists will behave, considering their Personality aspects, and how those aspects better fit together in order to increase their performance as group.

As a result we intend to create a supported statistical data in order to standardize virtual agents' behavior according to the real FFM aspects tested on group dynamics. This standardization will direct us toward to the creation of a Markup language to represent personality and its aspects on group dynamics, follow the experience from the brand new EmotionML (W3C, 2009).

Other potential application will be the insertion of SGD model into a Serious

game scenario, like the Second Life and School society (LORETO and GOUAÏCH, 2010), in order to create believability in the group of agents.

6. CONCLUSIONS

If virtual agents interact with people, they should achieve the suspension of disbelief in order to offer an interesting and believable interaction experience to users. To achieve this it is important that the agents' behaviors are consistent with a given Personality since people have a tendency to attribute Personality to interactive artifacts (REEVES AND NASS, 1996). The concept of Personality is also useful to create diversity in multi-agent simulations even if users do not directly engage in the interactions, for example, to explore different strategies in simulated societies. Personality is also important in the creation of interesting and coherent individualities that sustain the believability of virtual agents that interact with users.

This paper presented, partially, a computational model of Personality based on the Five Factor Model that created individuality in believable team interactions. Indeed, we presented a Case Study where we will obtain, as a result, a supported statistical standardized data defined as a pattern of agents' (real and virtual) behaviors in a group dynamics considering FFM. This standardization will enable us to use those extracted patterns in simulated societies (real or virtual) removing the needed of obliging users to answer long Personality Inventories, like NEO-IPIP Inventory (NUNES, 2009a), thus turning less intrusive the process of extracting people Personality, filling the gap of nowadays methods (DUNN et al, 2009).

Moreover, the results of this ongoing experiment will be used in other projects in development by authors.

ACKNOWLEDGMENTS

This work was supported by FCT (INESC-ID multiannual funding) through the PIDDAC Program funds (Portugal member). Indeed, this work was supported by UFS (PICVOL - Brazilian member).

ISSN 2176-171X

REFERENCES

Collins, B.E. and B.H. Raven. Group Structure: Attraction, Coalitions, Communication, and Power. In G. Lindzey and E. Aronson (Eds.). The Handbook of Social Psychology (2nd Edition) (Volume 4) Reading, Mass.: Addison-Wesley, 1969.

Damasio, A. R. Descartes' Error: Emotion, Reason, and the Human Brain. Quill, New York, 1994.

Digman, J. M. Personality structure: Emergence of the five-factor model. *Annual Review of Psychology*, vol. 41, pp. 417–440, 1990.

Dunn, G., Wiersema, J., Ham, J., and Aroyo, L. 2009. Evaluating Interface Variants on Personality Acquisition for Recommender Systems. In *Proceedings of the 17th international Conference on User Modeling, Adaptation, and Personalization: Formerly UM and AH* (Trento, Italy, June 22 - 26, 2009). G. Houben, G. Mccalla, F. Pianesi, and M. Zancanaro, Eds. Lecture Notes In Computer Science, vol. 5535. Springer-Verlag, Berlin, Heidelberg, 259-270.

EmotionML, W3C. 2009. (Available at http://www.w3.org/TR/2009/WD-emotionml-20091029/).

French, J. R. P. and Raven, B. H. Group Dynamics: Research and Theory. New York: Harper and Row, ch. Bases of Social Power, 1968.

John, O. P. and Srivastava, S. The big five trait taxonomy: History, measurement, and theoretical perspectives. *Handbook of Personality: Theory and Research*, Edited by Lawrence A. Pervin and Oliver P. John , pages 102–138. The Guilford Press, New York, second edition, 1999.

Johnson, J. A. Web-based personality assessment. *71st Annual Meeting of the Eastern Psychological Association*, Baltimore, USA, 2000.

Johnson, J. A. Ascertaining the validity of individual protocols from web based personality inventories. *Journal of research in Personality*, 39(1):103–129, 2005.

Johnson, J. A. Screening massively large data sets for nonresponsiveness in web-based personality inventories. *Invited talk to the joint Bielefeld-Groningen Personality Research Group*, University of Groningen, The Netherlands, 2001.

Loreto, Ines Di and Gouaïch, Abdelkader. An early early evaluation method for social presence in serious game. *2nd International Conference on Computer Supported Education 2010*.

Loyall, A. B.; *Believable Agents: Building Interactive Personalities*; Ph.D. thesis CMUCS-97-123; Carnegie Mellon University; May 1997.

Ma, S. Personality and Group Dynamics in Believable Multi-Agent Systems, *Instituto Superior Tecnico-Universidade Tecnica de Lisboa*. Dissertação de Mestrado, 2009.

Mcrae, R. R. and John, O. P. An introduction to the five-factor model and its applications. *Journal of Personality*, 60(2):175–216, 1992.

Nass, C. and Lee, K. M. Does computer-generated speech manifest personality? An experimental test of similarity-attraction. *CHI '00: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 329–336, New York, NY, USA. ACM, 2000.

Nass, C., Moon, Y., Fogg, B. J., Reeves, B. and Dryer, C. D. Can computer personalities be human personalities?. *International Journal Human-Computer Studies*, 43(2):223–239, 1995.

Nunes, M. A. S. N. Recommender Systems based on Personality Traits: Could human psychological aspects influence the computer decision-making process?. 1. ed. Berlin: VDM Verlag Dr. Müller. v. 1. 140 p., 2009.

Nunes, M. A. S. N. Psychological Aspects in lifelike synthetic agents: Towards to the Personality Markup Language (A Brief Survey). RENOTE. *Revista Novas Tecnologias na Educação*, v. 7, p. 1-11, 2009.

Nunes, M. A. S. N., Cerri, Stefano A., Blanc, N. Towards User Psychological Profile. *VIII Simpósio Brasileiro de Fatores Humanos em Sistemas Computacionais IHC*. Porto Alegre: Sociedade Brasileira da Computação, 2008. v. 1. p. 196-203, 2008.

Picard, R. W. Affective computing. MIT Press, Cambridge, MA, USA, 1997.

Prada, R., Ma, S., Nunes, M. A. S. N. Personality in Social Group Dynamics. *International Conference on Computational Science and Engineering- CSE '09*, 2009, Vancouver. v.4. p.607 – 612, 2009.

Prada, R. and Paiva, A. Believable groups of synthetic characters. *AAMAS '05: Proceedings of the fourth international joint conference on Autonomous agents and multiagent systems*. New York, NY, USA: ACM, 37–43, 2005.

Prada, R. and Paiva, A. Teaming up humans with autonomous synthetic characters. *Artificial Intelligence*, vol. 173, no. 1, 80–103, 2009.

Prada, R., Camilo, J., Nunes, M. A. S. N.. Introducing Personality into Team Dynamics. *ECAI - European Conference on Artificial Intelligence*. (2010), Lisbon. (accepted paper, to be published in august)

Reeves B. and Nass, C. "The media equation: how people treat computers, television, and new media like real people and places". Cambridge University Press, New York, NY, USA. (1996)

ISSN 2176-171X

Soldz, S. and Vaillant, G. E. The big five personality traits and the life course: A 45 years longitudinal study. *Journal of Research in Personality*, 33:208–232, 1998.

Wiki. (2010) Wikipedia (available at http://en.wikipedia.org/wiki/Social_group)