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Michelle Leonhardt Camargo

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UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

UNIVERSITÉ DE GRENOBLE

THÈSE

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dans l' École Doctorale **Mathematiques, Sciences et Technologies de l'Information (France)** et le **Programa de Pós Graduação em Ciência da Computação (Brésil)**

Modèle de communication affective pour Agent Conversationnel Animé basé sur des facettes de personnalité et des buts de communication "cachés"

Thèse soutenue publiquement le **13 mars 2012**
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"What we know is a drop,
what we don't know is an ocean."
— ISAAC NEWTON

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LIST OF ABBREVIATIONS AND ACRONYMS

AAAI	Association for the Advancement of Artificial Intelligence
AAMAS	International Conference on Autonomous Agents and Multi-agent Systems
AC	Affective Computing
ACL	Agent Communication Language
AEQ	Agent Evaluation Questionnaire
AI	Artificial Intelligence
BDI	Belief, Desire, Intention
BRF	Belief Revision Function
CA	Conversation Analysis
CG	Computer Graphics
COOP	International Conference on the Design of Cooperative Systems
DIVA	DOM Integrated Virtual Agents
DOM	Document Object Model
ECA	Embodied Conversational Agent
ECAs	Embodied Conversational Agents
FACS	Facial Action Coding System
FFM	Five-factor Model
FIPA	Foundation for Intelligent Physical Agents
GIA	Artificial Intelligence Group
GWT	Google Web Toolkit
H1	Hypothesis 1
H2	Hypothesis 2
H3	Hypothesis 3
HCI	Human-Computer Interaction
HCG	Hidden Conversational Goals

IJCAI	International Joint Conference on Artificial Intelligence
INRIA	Institut National de Recherche en Informatique et Automatique
IVA	Intelligent Virtual Agent
JASON	Java based AgentSpeak Interpreter Used with Saci For MultiAgent Distribution Over the Net
KQML	Knowledge Query Manipulation Language
LIG	Laboratoire d'Informatique de Grenoble
MAGMA	Modlisation d'Agents Autonomes en Univers Multi-agents
MAS	Multi-agent System
MMHCI	Multimodal Human-computer Interaction
MPEG4	Motion Picture Experts Group Layer-4 Video
NEO PI-R	Neuroticism Extraversion Openess Personality Inventory Revisited
NLI	Natural Language Interaction
NLG	Natural Language Generation
NLP	Natural Language Processing
OCC	Ortony, Clore, and Collins
OCEAN	Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism
OQ	Overall Questionnaire
PRAIA	Pedagogical Rational and Affective Intelligent Agents
PhD	Doctor of Philosophy
SFFC	Speech and Face to Face Communication
SIGART	(ACM) Special Interest Group on Artificial Intelligence
TRP	Transition-relevance Place
UFRGS	Universidade Federal do Rio Grande do Sul / Federal University of Rio Grande do Sul
XML	Extensible Markup Language

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ABSTRACT

Embodied Conversational Agents (ECAs) are intelligent software entities with an embodiment used to communicate with users, using natural language. Their purpose is to exhibit the same properties as humans in face-to-face conversation, including the ability to produce and respond to verbal and nonverbal communication.

Researchers in the field of ECAs try to create agents that can be more natural, believable and easy to use. Designing an ECA requires understanding that manner, personality, emotion, and appearance are very important issues to be considered.

In this thesis, we are interested in increasing believability of ECAs by placing personality at the heart of the human-agent verbal interaction. We propose a model relating personality facets and hidden communication goals that can influence ECA behaviors.

Moreover, we apply our model in agents that interact in a puzzle game application. We develop five distinct personality oriented agents using an expressive communication language and a plan-based BDI approach for modeling and managing dialogue according to our proposed model.

In summary, we present and test an innovative approach to model mental aspects of ECAs trying to increase their believability and to enhance human-agent affective communication. With this research, we hope to improve the understanding on how ECAs with expressive and affective characteristics can establish and maintain long-term human-agent relationships.

Keywords: Artificial Intelligence, Cognitive Systems, Embodied Conversational Agents, Personality Traits.

1 INTRODUCTION

Embodied Conversational Agents (ECAs) are intelligent software entities with an embodiment used to communicate with users, using natural language. In other words, ECAs represent a special kind of agent with conversational abilities and some kind of virtual representation. Figure 1.1 shows illustrative examples of ECAs.

Figure 1.1: Examples of Embodied Conversational Agents
REA (BICKMORE 2003), MARC (COURGEON; MARTIN; JACQUEMIN 2008), and Greta (POGGI et al. 2005)

Embodiment and conversational abilities are similar to those of humans: we all have a body and we all communicate somehow. Therefore, it is important to start this work with a brief discussion about agents. Russell and Norvig (1995) define Artificial Intelligence (AI) as a subfield of computer science studying agents that exhibit aspects of intelligent behavior. A variety of definitions can be found in literature to the word agent, each given by different authors to explain their understanding of the concept (some examples can be found in (MAES; KOZIEROK 1993; WOOLDRIDGE 1995). In other words, there is still no consensus about the meaning of the word among scientists. Due to this fact, Franklin and Graesser (1996) reviewed and discussed several agent definitions proposed by different researchers and constructed an agent taxonomy aimed at identifying the key features of agent systems. They tried not only to differentiate agents from traditional systems but also to clarify the concept. In the end, they provided a definition of an autonomous agent[1] that has been adopted by many researchers: a system situated within and a part of an

[1] Intelligent agents must operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state. Therefore they are also called autonomous agents.

environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to affect what it sense in the future.

Because of their characteristics (conversational abilities and embodiment), ECAs sense and act on their environment mainly through communication. Even when used for scenarios that are limited to only small talking, ECAs still have a common agenda: understand different input modalities, decide on the adequate behavior according to the environment where they act and their tasks inside this environment (based or not on some special influencer: personality, culture, emotion, among others), and generate output feedback (Figure **??**).

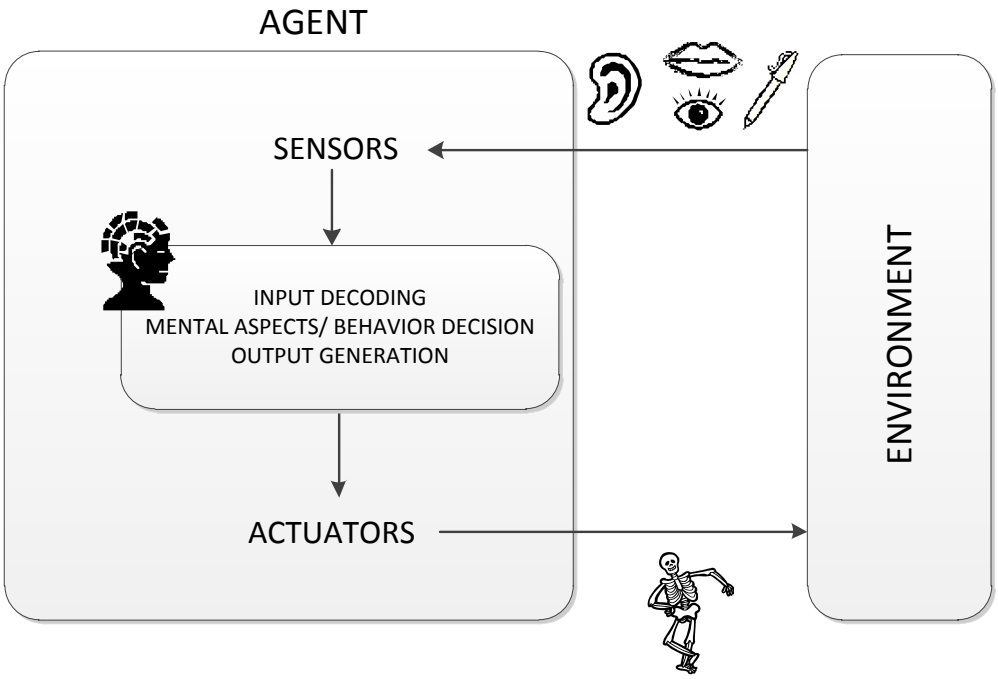

Figure 1.2: ECAs x Environment
Adapted from (RUSSEL; NORVIG 1995))

Several other technical terms can be found in literature while referring to ECAs: virtual characters, humanoids, talking heads, among others. The reason for that can be justified by the fact that the construction of such agents is complex and essentially interdisciplinary. The goal of the ECA research is to produce intelligent agents capable of certain social behaviors, using their visual representation as a way to reinforce the belief that they are a social entity (ISBISTER; DOYLE 2004). Considering the definition given above, for example, some of the fields that can be related to the construction of ECAs (in computer science) are: artificial intelligence (AI), natural Language processing (NLP), computer graphics (CG), human-computer interaction (HCI). Also, outside of the computer science field, one can easily understand the necessity of research on sociology, psychology, cultural anthropology, linguistics, and others in order to create such agents.

The general goal of researchers in the field of ECAs is to create agents that can be more natural, believable[2] and easy to use. Due to the broad scope of research and the

[2]We will discuss believability in ECAs later in this document

multidisciplinary of the field, many other investigations can arise in many different areas, leading researchers to face numerous questions: What kind of embodiment to use? Realistic? Artistic? Cartoon-like?; What parts of the body to represent? Face? Full-body?; What kind of figure to represent? A human figure or a different kind of character (a cat, a dog, an object instead of a living being)?; What kind of modalities to explore?; What personality model to consider? Will the ECA have emotions?; How to deal with culture aspects?.

In the preface of their book dedicated to the topic, Ruttkay and Pelachaud (2004) discuss the fact that research groups generally do not have the resources to implement substantial solutions to all the problems involved in building an entire ECA. Considering all the research requirements to build a full ECA (embodiment, input-recognition system, a behavior engine, some model of personality and possibly of emotion, output feedback - more detail on the relevant design aspects of ECAs will be presented in chapter 2), it is natural to conclude that that this field represents a challenge in all disciplines involved in its conception.

Later in this chapter, we will present our motivation to carry out research in this challenging area, contextualizing and describing the research aims and goals, in order to illustrate our specific contribution to the field.

1.1 Overview

As presented above, ECA research is a very challenging and ambitious endeavor and one difficulty in ECA research is the vague description of the problem that researchers are trying to solve. Several questions can be addressed while constructing ECAS and the field itself is not yet consolidated. Due to this fact, we can find in literature efforts to create some kind of taxonomies and definitions to help researchers to clarify and to contextualize their work. Isbister and Doyle (2004), for example, proposed a taxonomy of the research areas contributing to the creation of ECAs (Figure 1.3). In their work, they claim that there are two reasons to do so. First, to make the distinctions between the particular research areas clear, so that researchers can clearly indicate where they are making novel contributions and where they are not. Second, the hope was that a basic taxonomy would be a starting point for developing evaluation criteria for each area. They also define several ways in which researchers in the community could use the proposed taxonomy: to clarify and communicate primary skills; to assemble appropriate terms during project planning; to set evaluation benchmarks, to contextualize work for others in and outside the community.

The proposition of the taxonomy starts by following the approach of Franklin and Gresser (1996): examining several foundation definitions for conversational agents, intelligent characters, believable agents (and other commonly terms used to describe ECAs). They decide, then, to define a set of four research concentrations within the ECA field, each with its own standards:

- Believability → Research on how to create the "illusion of life" for those who observe and and engage with the embodied agent. According to them, the approach is to selective imitate and heighten qualities of humans and animals that will engage a person's belief that this is an animate creature. Even if the person does not fully believe the agent is real, the user will still be able to enjoy and engage with the agent, and it will not be disrupted by feelings that the agent is somehow mechanical or machine-like. Inside believability, problems can be divided in two classes: making

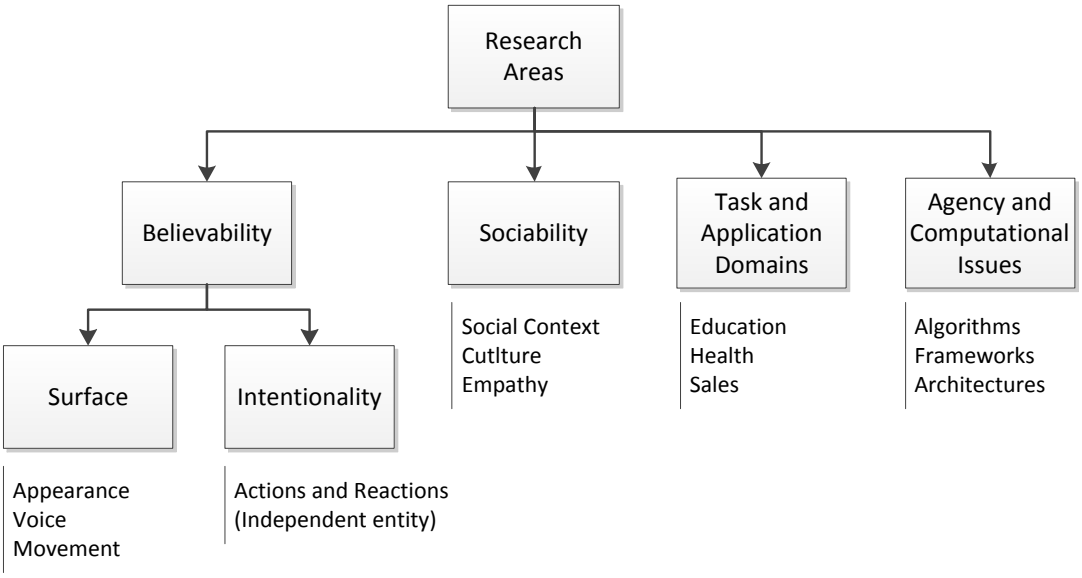

Figure 1.3: Research Areas Contributing to the Creation of ECAs
(ISBISTER; DOYLE 2004)

the surface of the agent believable (regarding appearance, voice, and movement, for example) and making the intentionality of the agent believable (regarding actions and reactions that create the impression of an independent entity with goals and feelings).

- Sociability ⇀ research focusing on producing lifelike social interactions between ECAs and users. The authors claim that the goal is to produce both theories and techniques that will enable the creation of such interactions. This specialty innovates and enhances the manner in which people interact socially with ECAs, including conversational skills, appropriate interpersonal reactions and adaptations, awareness of social context (physical or cultural), empathy, and the ability to work from individual goals toward mutual social agendas with the user. It also includes designing fluid and natural methods for interaction with agents, such as voice or gesture recognition.

- Task and Application domains ⇀ research focusing on creating ECAs that support real-world task domains, such as education, health care, banking, or sales. The important point is that this kind of research should have measurable target outcomes for users. This specialty, rather than beginning from generally applicable qualities of ECAs, begins from a particular application domain in which ECAs may provide value. The focus is directed first to researching the application domain, designing and implementing an ECA to meet the needs and fill a suitable role within that domain, and second, testing the completed agent with real users, using benchmarks drawn from the domain. Also, researchers working on this specialty must generate agents that are still sufficiently believable and sociable to support the task context, but their focus is on developing these qualities around the particular task at hand.

- Agency and Computational issues ⇀ research concerned with the creation of algorithms, systems, architectures and frameworks that control ECAs. This ranges from

work on particular subsystems such as vision, speech recognition, natural language understanding and generation, and kinematics for motion control, to complete architectures for creating autonomous agents that incorporate memory, planning, decision making, behavior selection, and execution. The authors explain that work on agency specifically for ECAs tend to focus on systems that either make trade-offs that favor believability rather than traditional computational measures of success (such as optimality or correctness) or on the creation of control or reasoning systems that mimic living beings in ways that make it easier or more natural to produce believable behaviors.

One could argue that the taxonomy proposed by the authors is not yet fully applicable since research in one concentration can influence and interfere into another concentration (e.g. making the intentionality of the agent believable through some kind of social aspect and, consequently, through the development of a reasoning mechanism for dealing with the chosen aspect).

1.2 Contextualization

This work is inserted in the Artificial Intelligence group [3] (GIA) of the Federal University of Rio Grande do Sul (UFRGS) - Porto Alegre, Brazil, and the research this group carries out on AI and its applications. Additionally, this thesis is being developed in collaboration with MAGMA [4] team of the Laboratoire d'Informatique de Grenoble (LIG) [5] - Grenoble, France. MAGMA team is interested in engineering MAS (Multi-agent systems), modeling and simulating complex social systems, and group dynamics.

This thesis is also inserted in the scope of PRAIA Project (Pedagogical Rational and Affective Intelligent Agents) - international project of cooperation between UFRGS and LIG (France), supported by Capes-Cofecub. This project involves three areas of research which are: Education and Computer Science (developing computational solutions for a more effective learning), and Cognitive Science (handling emotions inside educational environments). The main goal of the project is to develop methodologies, models, tools and solutions for handling student affect in the interaction between tutor and student (JAQUES et al. 2009).

The research in PRAIA project is guided by the following questions:

- How to model and to represent student emotions?
- How to recognize student's emotions?
- How to respond appropriately to student's emotions?
- How to develop methods and techniques to evaluate our research?

In order to respond to those questions, some activities are defined in the project, which are:

[3] Artificial Intelligence Group (GIA) - http://www.inf.ufrgs.br/gia/
[4] Modlisation d'agents autonomes en univers multi-agents (MAGMA) - http://magma.imag.fr/
[5] Laboratoire d'Informatique de Grenoble (LIG) - http://liglab.imag.fr/

- Analysis and study the existing methods and techniques for recognizing, modeling and expressing emotions;
- Conception of new methods and techniques for recognizing, modeling and expressing emotions;
- Development of a prototype using the methods and techniques conceived during the first part of the project;
- Contribution to the state-of-the-art on the evaluation of systems designed with aims of recognizing, modeling and expressing emotions.

1.3 Motivation and Objectives

The motivation for the study of ECAs, inside PRAIA project, started by trying to answer one particular research question that guides the project: *How to respond appropriately to student's emotions?* We believe that ECAs represent a promising solution for responding appropriately to student's in educational environments. Another influencer of this motivation is the fact that previous work with pedagogical agents inside the group demonstrated that providing feedback and guidance using pedagogical interface agents can be helpful in encouraging students to stay engaged in the educational process (JAQUES; VICARI 2007).

This work, however, can not be placed inside the "*task and Application domains*" concentration of the taxonomy presented in section 1.1. We are not interested in following previous approaches inside the group by designing and implementing an agent to meet the needs and fill a suitable role within one specific educational environment. We believe that trying to make a general contribution in other concentrations will increase the possibilities of future research inside both groups since both groups have other research interests outside educational applications.

In this thesis, we are interested in increasing believability of ECAs, specifically considering the second class of believability problems: making the intentionality of the agent believable regarding actions and reactions that create the impression of an independent entity with goals and, specially, feelings (emotions). But what is the definition of emotion? According to Scherer (2005) the concept of 'emotion' presents problem because the term is used very frequently but the question 'What is an emotion?' rarely generates the same answer from different individuals. He define emotion as the episode relatively brief of coordinated changes in several components for all or most organic systems to the evaluation of an external or internal event as being of major significance (SCHERER 2000). Another definition can be found in the Encyclopedia of Applied Psychology (CAMPOS; KELTNER; TAPIAS 2004; MESQUITA; HAIRE 2004): emotion is a short-lived, biologically based pattern of perception, experience, physiology, and communication that occurs in response to specific physical and social challenges and opportunities.

One must understand, however, that emotion is not the only aspect that influences everyday interactions. Other definitions taken from the work of Scherer (2000) help to better understand some of the other affective aspects that are also important. He suggests four types of affective phenomena that should be distinguished from emotion proper, although there may be some overlap in the meaning of certain words:

- Mood $\rightarrow$ diffuse affective state that consists in changing (low intensity, long duration) in the subjective feeling, which is the reflection in the central nervous system

of all changes in other body systems during an episode). Some examples: irritable, depressed, cheerful.

- Interpersonal stances $\rightarrow$ affective stance taken in relation to another person according to a specific interaction. Some examples: supportive, cold, warm.

- Attitudes $\rightarrow$ relatively tolerant, affectively colored beliefs, preferences and predisposition in relation to people or objects. Some examples: loving, hating, desiring.

- Personality traits $\rightarrow$ stable personality dispositions and behavior tendencies, typical of a person. Some examples: anxious, nervous, envious.

Therefore, our contribution lies on trying to advance the state of the art by developing agents that are believable interlocutors and attractive to users. We are interested in placing personality at the heart of the human-agent verbal interaction. The reason for choosing personality as a central point of study is due to the fact that personality influences emotions and attitudes and help to increase believability of ECAs (as it will be discussed in chapter 2).

In order to achieve our goal, this thesis present the following objectives:

- Provide background literature regarding Embodied Conversational Agents and Affective Communication;

- Model how to relate personality, attitudes and verbal communication in ECAs.

- Define and implement five different facets of personality in Embodied Conversational Agents (in a puzzle game scenario[6]) in order to validate our proposed model.

In summary, we are presenting and testing an innovative approach to model verbal communication in ECAs trying to increase their believability and to enhance human-agent affective communication. Our focus is to propose a model relating personality facets and hidden communication goals that can influence ECA verbal behaviors. Different from other approaches relating personality to conversational agents [7], our approach proposes that verbal conversation of a conversational agent is influenced by personality facets. In our approach, an agent would suffer the influence of hidden conversational goals (that one can assume as natural goals that are present in particular personality types independent of the topic of conversation and task being performed) together with the particular goals of the contextual situation where the agent is inserted.

We are applying our model in agents that interact in a puzzle game application. We are developing five distinct personality oriented agents using an expressive communication language developed by (BERGER 2006) [8] and a plan-based BDI approach [9]. for modeling and managing dialogue according to our proposed hidden conversational goals. We believe that the use of both will provide more expressibility for our agents when interacting with users.

[6]Reasons for choosing a puzzle game scenario will be explained later in the document.
[7]Some of these approaches will be presented in chapter 2.
[8]This language will be presented in detail in chapter 3
[9]Also presented in detail in chapter 3

1.4 Final considerations and Thesis Outline

This chapter has outlined the research problem and the purpose of the study. We started by defining ECAs and discussing the particularities of the research area. We presented research efforts trying to explain and contextualize the field. Moreover, we discussed our motivation to do this work and presented the project in which this thesis is inserted. Although we are focusing on personality as an influencer of believability and emotion manifestation in ECAs, this thesis will not explore psychological theories of emotion/personality or discuss other ECAs implemented with such emotional characteristics. The reason for that lies on the fact that we were earlier influenced by some of the technologies used in our implementation (the expressive conversation language, for example). Also, placing current works inside only one category of the taxonomies we are presenting still represents a hard task because of the broad scope of research. Some works that can illustrate the field of ECAs can be found in major conferences (see chapter 7, section 7.2 for specific information on leading AI scientific conferences that held workshops and special tracks dedicated to the development of ECAs in the past 5 years)

Following this introductory material, the remainder of this thesis is organized as follows:

- Chapter 2 will present literature review that will provide readers with a common point of reference about ECAs field and affective communication in ECAs. The chapter will begin with a discussion of affective communication and believability in ECAs and will present another taxonomy proposed to define relevant design aspects of ECAs. The taxonomy will illustrate the importance of several mental aspects to increase ECA affection and believability. The chapter will finish with a presentation of some related works considering personality aspects and ECAs.

- Chapter 3 will provide discussion concerning dialogue in conversational systems. It will explain characteristics that differ dialogue from other kinds of discourse. It will then discuss dialogue management in conversational agents and will present the belief, desire, and intention model. Finally, it will present the expressive conversational language that is used to develop our distinct personality oriented agents.

- Chapter 4 will introduce our proposed model. The first part will present the platform developed as a study case scenario and will justify why choosing this specific scenario and platform. The second part will present the proposed model relating personality facets and hidden communication goals that can influence ECA behaviors. We will introduce the grounding model of personality and emotion we are using to propose our hidden conversational goals.

- Chapter 5 will present the implementation of our agents using an expressive communication language and a plan-based BDI approach for modeling and managing dialogue according to our defined hiden conversational goals (we will present one personality facet implementation in detail). We will present examples of dialogue of other personality oriented agents we have developed. The chapter will also discuss embodiment issues of the developed agents.

- Chapter 6 will describe the evaluation of the developed prototype (agents according to the proposed model). First it will present literature about ECAs evaluation in general. Later it will present the specific evaluation strategies adopted in this work (method and results).

Finally we will conclude this work by presenting our final considerations (chapter 7). We will list our contributions, demonstrate the importance of the topic, and present future endeavors in this specific area of knowledge.

2 AFFECTIVE COMMUNICATION IN ECAS

Chapter 1 presented one effort to create some kind of taxonomy and to set definitions to help researchers to clarify and to contextualize their work (taxonomy proposed by Isbister and Doyle (2004)). In the same chapter, we presented our motivation to do research in the area (which is to develop agents that are attractive and closer to users and that are believable interlocutors). We defined believability (according to the taxonomy) as creating the "illusion of life" for those who observe and engage with agents. Moreover, we mentioned that believability depends not only on the physical appearance of an agent (surface) but also on emotional abilities and personality or social capabilities (intentional capabilities).

The purpose of this chapter is to discuss affective communication in ECAs. It is intended to provide background that will determine the direction of this study. This review is not intended to be exhaustive. Instead of discussing emotion and affective computing in depth, we will focus on providing the reader with background on the necessary requirements to create a believable/affective ECA (sections 2.1 and 2.2). In addition, we will present some related work and will discuss the differences to our approach (section 2.3).

2.1 Affective Communication and Believability in ECAs

Affective communication is communicating with someone (or something) either with or about affect. According to Picard (1997), most of us are experts in expressing, recognizing and dealing with emotions. However, affective communication that involves computers represents a vast but largely untapped research area. Rosalind Picard (1997) defines affective computing as computing that relates to, arises from or deliberately influences emotions. She argues that computers can acquire the benefits of emotions by adapting them: flexible and rational decision-making, ability to address multiple concerns in an intelligent and efficient way, ability to have human-like attention and perception, among numerous other interactions.

Affective aspects are important while developing ECAs since emotion modulates almost all modes of human communication: facial expression, gestures, posture, tone of voice, respiration, even skin temperature. It is natural and usually subconscious for people to express affection by using such modalities. Buisine and colleagues (2004) argue that, in order to increase believability in ECAs, attempts are made to give them some aspects of emotions.

Current literature shows that the term *believability* does not have a formal and widely accepted definition but authors usually agree that emotional behavior and personality have a high impact on agents' believability (IJAZ; BOGDANOVYCH; SIMOFF 2011). The notion of believability originates in the field of animation and story telling where be-

lievability means that people can forget skepticism and feel that the character is real (LOYALL; BATES 1997). In other words, the notion of believability in agents is highly correlated to the expression of emotional characteristics which are influenced by agent individuality (personality) and contextual influences.

This notion is confirmed in the work of Niewiadomski, Demeure, and Pelachaud (NIEWIADOMSKI; DEMEURE; PELACHAUD 2010) where they conducted experiments trying to analyze several factors influencing the perceived believability of virtual assistants. They tested three main hypotheses: (H1) A virtual agent will be judged warmer, more competent and more believable when it displays socially adapted emotions; (H2) The judgment of believability is correlated with the two socio-cognitive factors of warmth and competence; (h3) The judgement of an agent as believable is different from creating a human-like relation with it. In the end, they concluded that an agent that uses appropriate verbal (speech, prosody) and nonverbal (facial expressions, gestures) communication channels is more believable that the one using only speech with prosody or only facial expressions and gestures. Another conclusion is that the perception of warmth and competence are correlated with the perception of believability indicating that socio-cognitive factors (like the ones they tested - warmth and competence) are taken into account while evaluating the agent's believability. They suggest that even if an agent is perceived as believable it does not imply that humans will create human-like relations with it.

Even if not creating human-like relations with virtual agents, the importance of considering aspects that increase believability in agents is undeniable. Catrambone and colleagues (2004) argue that designing an ECA without this implication in mind (or a 'one size fits all' approach) may not provide enough flexibility for conversational style interactions in which manner, personality, emotion, and appearance seem to be so important. Next section will present a taxonomy of relevant design aspects of ECAs that consider important aspects that can help increase believability in ECAs.

2.2 A taxonomy of relevant design aspects of ECAs

In the eyes of the user, an ECA is perceived as a black box that receives information in a variety of modalities and produces output as a reaction to the input (figure 2.1).

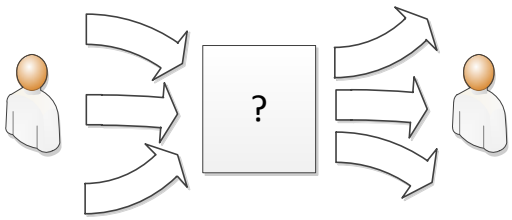

Figure 2.1: ECAs as perceived by users
Black box receiving input and producing output

Researchers and developers, on the other hand, know that creating an ECA means having more than a black box receiving and producing output. Many other aspects have to be considered to perform this challenging task: an ECA should not only have an embodiment, but also an input-recognition system, a behavior engine, some mental model, and some output feedback. The taxonomy proposed by Ruttkay, Doormann and Noot (2004) defines relevant design aspects of ECAs. Figure 2.2 shows the complete taxonomy (we

will later discuss in detail). This taxonomy shows that the behavior of an ECA depends on several parameters together with the application that motivates the interaction.

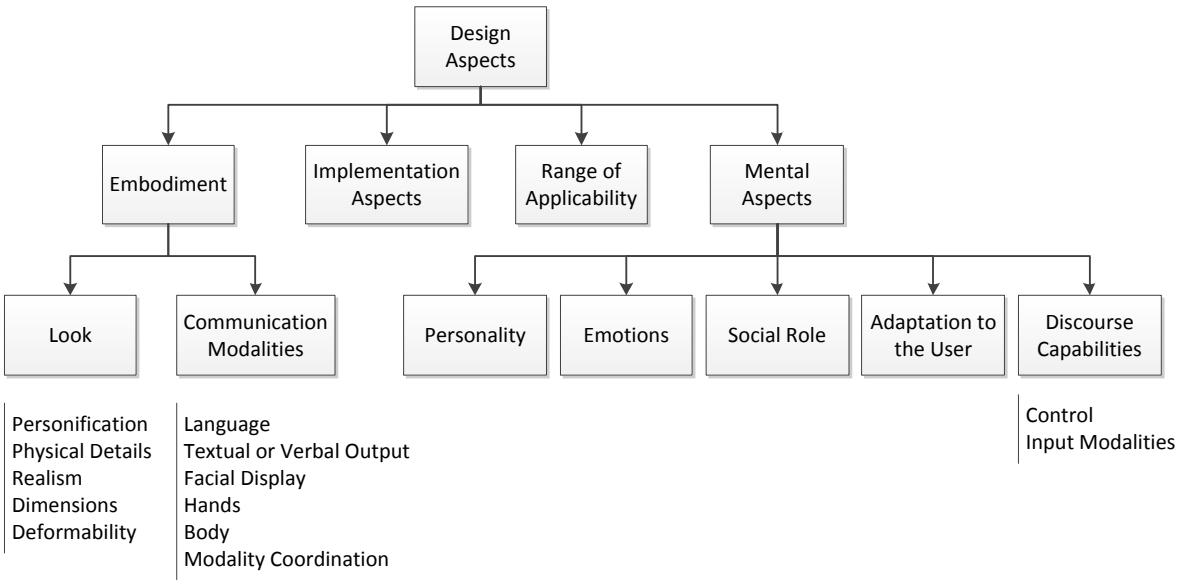

Figure 2.2: Taxonomy of Relevant Design Aspects of ECAs
(RUTTKAY; DORMANN; NOOT 2004)

The authors argue that one of their objectives is to encourage the ECA community to start agreeing upon a common set of concepts used to report on ECA research. Other objectives include the desire to provide a framework to categorize the extensive literature on ECA design and evaluation and hence to help the community to interpret and understand the findings reported. Considering a design perspective, the authors explain that users will react to an ECA based on both what it communicates, and how. Based on that belief, they define some aspects of ECAs that need to be dealt with during its design and construction.

Although their discussion is more focused on design and evaluation issues, proposing guidelines to design ECAs, what is important to mention now is the discussion about what aspects must be taken into consideration during ECA conception and development, which are:

- Range of applicability → the term refers to the application context (presentation ECAs? information ECAs? educational ECAs?). The term also refers to the desired modularity of the ECA and conformation to standards.

- Mental Aspects → the term refers to the way humans use the body and voice to express different aspects of a piece of factual content, according to some specific situation. Mental aspects can also be separated in some categories: personality, social role, emotions, adaptation to the user, discourse capabilities (control and sensing capacities). Table 2.1 presents some design questions that can guide each subcategory.

- Embodiment → the term embodiment is used in a broad sense, including all aspects which contribute to the physical appearance of the agent: body design and rendering, voice, head, face, gestures, posture, among others. According to the

Table 2.1: Question Guidelines considering Mental Aspects

(RUTTKAY; DORMANN; NOOT 2004)

Category	Subcategory	Design Questions
Mental Aspects	Personality	Will the ECA have personality? What model?
	Social Role	What will be the social role of the ECA? How this role influence embodiment?
	Emotions	What emotional states can the ECA get into?
	Adaptation to the user	Will the ECA tune his behavior according to the characteristics of the user?
	Discourse capabilities	Control → How is the ECA controlled? Input Modalities → What should be perceived of the user? How?

authors, embodiment can be separated in two categories: look and communication modalities. Tables 2.2 and 2.3 present some design questions that can guide each subcategory. Look concentrates on appearance, dealing with personification, physical details, realism, dimensions, and general deformability aspects. Communication modalities concentrate on communication aspects and deals with different issues regarding verbal and non-verbal communication: language, textual or verbal output, facial display, hands, body, modality coordination, and motion generation.

Table 2.2: Question Guidelines considering Look

(RUTTKAY; DORMANN; NOOT 2004)

Category	Subcategory	Design Questions
Look	Personification	Living creature or non-living object?
	Physical Details	What parts of the body will be present in the model?
	Realism	Realistic? Artistic? Cartoon-like? Mix?
	Dimensions	2D? 3D?
	General Deformability	What features can be moved and deformed?

Table 2.3: Question Guidelines considering Communication Modalities

(RUTTKAY; DORMANN; NOOT 2004)

Category	Subcategory	Design Questions
Communication Modalities	Language	In what language will the ECA communicate?
	Textual or Verbal Output	Will the ECA communicate using textual or verbal output? How to produce verbal feedback?
	Facial Display	How the ECA will use the face?
	Hands	Will hands be used? How?
	Body	How will the body be used?
	Modality Coordination and Motion Generation	How are the different modalities coordinated? What are the motion characteristics of the ECA?

- Implementation aspects $\rightarrow$ the term refers to implementation characteristics and technical requirements.

2.3 Related Work: ECAs and Personality

Section 2.1 presented personality as an important factor to increase believability in ECAs. Furthermore, section 2.2 confirmed the importance of personality in ECAs by placing it as a design question inside the mental aspects category of the relevant design aspects of ECAs. This section will present literature showing how personality is being addressed in such kind of agents.

Bevacqua, Mancini, and Pelachaud (2008) propose a system that computes the behavior of a listening agent by encompassing the notion of personality. Their work is inserted inside a project aiming to build an autonomous talking head able to exhibit appropriate behavior when it plays the role of the listener in a conversation with a user. More specifically, the authors are interested in building a real-time ECA endowed with recognizable personality traits while interacting with users in the role of the listener. In order to do so, they propose a model that provides a static definition of such an ECA on the base of what they call a baseline: (i) the preference the agent has in using each available communicative modality (e.g., head orientation, eyebrows movements, voice and so on) and (ii) a set of parameters that affect the qualities of the agent's behaviour (e.g. wide vs. narrow gestures). The baseline is fixed depending on the agent's personality traits. In summary, they propose a system where the agent's personality traits are used to manually determine the agent's behavior tendencies, that is, the preference the agent has in using each modality and also the expressivity of behaviour.

Other works in literature that investigate patterns of human behaviors according to personality can be found varying from a general approach of creating models to relate emotions, non-verbal behaviors, and personalities (POZNANSKI; THAGARD 2005) to specific relations between modalities of non-verbal communication and personality traits (ARYA et al. 2006) or preferences in appearance and personalities (SYRDAL et al. 2007). These studies also concentrate on non-verbal attitudes and behaviors. Different from the works presented above, we are focusing on verbal ways to express some particular personality characteristic of an agent. Also, although some works do model the relation between

personality, emotion, and behavior inside game scenarios (BALL; BREESE 2000), the difference from their work and our approach is that they consider a more generic model of personality (not considering specific facets of personality) than the one we are using in this thesis.

Literature related to our work exists not only on the field of ECAs, but also on the field of natural language generation. Rowe, Ha, and Lester's work (ROWE; HA; LESTER 2008) propose an archetype driven character dialogue generator for narrative scenarios. Their dialogue generator is based on the notion of archetypes, which are narrative-theoretic blueprints of well-established sets of traits for a particular character and role, such as fears, goals, motivations, and personality characteristics. According to the authors, archetypes are adopted because of their power to define consistent sets of character traits that are both familiar and believable to audiences. The proposed archetype-driven model of character dialogue generation employs probabilistic unification grammars in order to simultaneously consider multiple sources of information (character archetypes, narrative history, and communicative goals) to dynamically generate character appropriate dialogue that achieves specific communicative goals for specific plot contexts.

Considering the work Rowe, Ha, and Lester (2008), the difference from our approach lies on the fact that instead of using archetypes based on Schmidt's work (SCHMIDT 2001) [1], we are using a generic grounding model of personality facets (based on personality traits) [2] to propose a model to generate hidden communication goals/intentions in our agent.

Another work that can be classified as similar to the one presented in this thesis is the work of Walker, Cahn, and Whittaker (WALKER; CAHN; WHITTAKER 1997) where the authors introduce the notion of Linguistic Style Improvisation, which is a theory and set of algorithms for improvisation of spoken utterances by artificial agents focused on interactive story and dialogue systems. This linguistic style improvisation is concentrated on semantic content, syntactic form and acoustical realization (which the authors call a strategy for realizing a particular communicative intention). Their work uses a set of parameters to define the chosen linguistic style of an agent (social distance, agent's public image (autonomy or approval), and hierarchy between interlocutors). As our work, they also use speech act theory as a base to define the linguistic style of agents. According to them, linguistic style helps listeners to define agent's character and personality.

Regarding the work of Walker, Cahn, and Whittaker (1997), our approach could be seen as complement to what they proposed since we are proposing a model based on personality that can change the linguistic style of a conversational agent. This model could be seen as a parameter that could somehow influence their proposed linguistic style parameters in some sort of way [3]). However, our work differs from them in the sense that we are concentrating on the influence of certain personality facets on the communicative intentions of an agent and the choice of how to communicate in a long-term way.

[1]The definition of the archetypes used on the work of Rowe, Ha, and Lester's work (ROWE; HA; LESTER 2008) took in consideration the work of Schmidt (SCHMIDT 2001) who wrote a book for writers struggling with characterization. Schmidt looked to mythology for such types as Aphrodite, Artemis, and Zeus, and she concisely outlined each type's cares and concerns, strengths and weaknesses, and likely reaction to common problems.

[2]The grounding personality theories used in our work will be explained later.

[3]How to do so would require particular studies on the topic

2.4 Final Considerations

This chapter presented a definition of Affective Computing and discussed about the importance of the field while developing ECAs. Moreover, the chapter complemented the introduction and highlighted the importance of this thesis by explaining the complexity of the field through its characteristics. The taxonomy of research areas contributing to the creation of ECAs (presented in chapter 1) provides means to understand our contributions to the field while the taxonomy of relevant design aspects of ECAs (presented in this chapter) contributes to understand the aspects that must be taken into consideration during ECA conception and development.

The next chapter will continue our literature review. We will discuss one key component of this research (also very important when developing conversational agents): dialogue. Since this work aims to enhance affective communication between agents and users (focusing on verbal communication and its relation to personality), we will provide some discussion on dialogue and its importance when designing conversational agents. We will first contextualize dialogue and will continue by explaining the importance of dialogue management in such agents. We will explain how to use a belief-desire-intention approach for dialogue management. Later, we will present the expressive conversational language (BERGER 2006) which is used to model and implement dialogue of some agents according to the model proposed in this thesis.

3 AN EXPRESSIVE CONVERSATIONAL LANGUAGE TO MODEL DIALOGUE IN ECAS

Chapter 2 presented an overview of affective communication in ECAs. The focus of this chapter is to discuss dialogue in conversational agents (section 3.1) and introduce the reader to some of the the specific works that are used as base for our approach. Section 3.2 will explain the importance of dialogue management in conversational agents and section 3.3 will present the BDI (Beliefs-Desires-Intentions) model (BRATMAN 1987; RAO; GEORGEFF 1991) which is used to manage dialogue in our agent.

The chapter will introduce the Expressive Conversational Language (BERGER; PESTY 2005; BERGER 2006) (section 3.4) also used as a base for our work. The Expressive Conversational Language is an agent conversational language created to enrich communicational abilities of conversational agents so that they may be able to express their feelings and their attitudes. The intention is to enable artificial agents to function in a more advanced way that corresponds to the philosophical, psychological and linguistic realities of communication.

3.1 Overview

According to the book "Speech and Language Engineering" (RAJMAN 2007), dialogue can be defined as a connected sequence of information which provides coherence over the utterances, and a context for interpreting utterances. Jurafsky and Martin's (2000) research point to the fact that dialogue is a key component when developing conversational agents and they present characteristics that differ dialogue from other kinds of discourse (related groups of sentences):

- Turn-taking Behavior ⇀ In natural conversation, people need to quickly figure out who should talk next and when they should talk. Studied by the field of Conversation Analysis (CA), turn-taking behavior generally is governed by a set of turn-taking rules that occur in a transition-relevance place (TRP) (SACKS; SCHEGLOFF; JEFFERSON 1974), that is, a place where the structure of the language allows the shift to occur. Jurafsky and Martin (2000) present a simplified version of Sacks' rules: (i) if during the turn the speaker has selected A as the next speaker then A must speak next; (ii) if the current speaker does not select the next speaker, any other speaker can take the next turn; (iii) if no one else takes the next turn, the current speaker may take the turn.

- Utterances ⇀ Turn-taking behaviors can lead to specific utterances (QUESTION-ANSWER, GREETING-COMPLIMENT) that are very important during dialogue

and dialogue modeling. Also, TRP usually occurs at utterance boundaries. Jurafsky and Martin's (2000) suggest that algorithms for utterance segmentation are usually based on boundary cues: (i) clue words tend to occur at the beginning and end of utterances); (ii) some specific words often indicate boundaries; (iii) prosody;

- Grounding ⇀ During dialogue, speaker and hearer must establish common ground (set of things that are mutually believed by both speakers). Common ground can be indicated (during conversation) by some methods presented in table 3.1 (created based on research of (JURAFSKY; MARTIN 2000)).

Table 3.1: Methods to indicate common ground during conversations

Method	Characteristic	Example
Acknowledgment token	short utterance or gesture which acknowledge the previous utterance in some way, often cuing the other speaker to continue talking	nod, continuer words: uh-huh, mm-hmm, yeah
Continued attention	B shows that (s)he is continuing to attend and therefore remain satisfied with A's presentation	—
Relevant next contribution	B starts in on the next relevant contribution	—
Demonstration	demonstration of understanding meaning	paraphrasing, reformulating, collaboratively completing other's utterance
Display	display verbatim of other's presentation	—

- Conversational Implicature - conversation is guided by a set of maxims (Table 3.2) which play a guiding role in the interpretation of conversational utterances (GRICE 1975).

Considering the characteristics presented above, it is obvious that dialogue do follow certain conventions and/or protocols that participants naturally adopt. Participants are able to perform dialogue even when little linguistic information is present in utterances. The reason for that lies on the participant's cognitive skills, i.e., their ability to perform inference based on a background knowledge and assumptions on the other participants' mental states.

3.2 Dialogue in Conversational Agents: The Dialogue Management

The dialogue manager is the component of conversational agents that controls the interaction with the user, deciding about the actions of the agent's side of conversation. The dialogue manager is also responsible for handling dialogue control tasks (RAJMAN 2007):

Table 3.2: Conversational Implicature

Set of Maxims of Conversation (GRICE 1975)

Maxim of	Description	Implications
Quantity	Be exactly as informative as is required	1. Make your contribution as informative as is required 2. Don't make it more informative than is required
Quality	Try to make your contribution one that is true	1. Do not say what you believe to be false 2. Do not say that for which you lack adequate evidence
Relevance	Be relevant	Be relevant
Manner	Be perspicuous	1. Avoid obscurity of expression 2. Avoid ambiguity 3. Be brief 4. Be orderly

- Dialogue Act Recognition ⇀ representation of the utterance indicating the type of the dialogue act.
- Disambiguation ⇀ solve ambiguities and decide among different possibilities (using, for example, dialogue history or contextual information).
- Confirmation ⇀ confirm the intention of the user in case where difficulties in dialogue act recognition persist.
- Error Handling ⇀ dealing with erroneous situations.
- Filling in missing information ⇀ Infer information when the user does not provide all the information required by the application.
- Context Switching ⇀ managing different tasks at the same time.
- Grounding ⇀ signaling grounding information.
- System response ⇀ performing action and responding to the user.

It is important to mention that all the presented dialogue control tasks are not essential because they depend on the task being performed. A conversational system designed with no specific task besides talking about any topic will probably not deal with filling in missing information, for example.

3.3 Dialogue Management using a BDI approach

One of the best known approaches to the development of cognitive agents is the BDI (Beliefs-Desires-Intentions) model (RAO; GEORGEFF 1991) that implements the principal aspects of Michael Bratman's theory of human practical reasoning (BRATMAN 1987). Practical reason is the general human capacity for resolving, through reflection,

the question of what one is to do. BDI agents are systems that are situated in a changing environment, receiving continuous perceptual input, and taking actions to affect their environment, all based on their internal mental state.

Agents in this model have three mental states: beliefs, desires, and intentions. **Beliefs** represent the understanding of the world where the agent is inserted, that means, the agent's knowledge about the world. This information may be incomplete or incorrect because the world is dynamic. **Desires** are the states of the world that an agent might like to accomplish. They can be inconsistent with other desires and they do not lead directly to actions (desires represent motivation for acting intentionally). **Intentions** are the states of affairs that the agent has decided to work towards. They reflect decisions an agent has made about its future actions.

Mental states are attributed to agents while they attempt to assess and weigh their reasons for action, the considerations that speak for and against alternative courses of action that are open to them. Practical reasoning is composed by at least two processes: deliberation and means-end reasoning. The first is the process that involves deciding what state of affairs the agent will pursue (intentions) while the latter is the process that defines how the agent will achieve the states selected during deliberation (planning).

A general BDI architecture is shown in figure 3.1. This architecture is composed of a set of current beliefs, a belief revision function (BRF), a generation function, a set of current desires, a function to determine the agent intentions, a set of current intentions, and an action selection function. The BRF determines a set of beliefs based on a perceptual input and on the agent current beliefs; the option generation function determines the agent desires based on current beliefs and intentions; The action selection function determines an action to be performed.

Concerning dialogue management, a BDI architecture offers the advantages of a complex but modular approach to designing dialogue systems, in that the plans used by the BDI agent are independent chunks of knowledge associated with particular communicative goals. When hearing an utterance, the conversational agent must be able to understand more than what the utterance means on the surface. The conversational agent must be able to understand why did the user utter what he did and what was he trying to accomplish by uttering it. Summarizing, the agent must understand the communicative intentions of the user. After, the agent have to decide what to do in response to those intentions: perform some action or utter something back (or both).

Using a BDI approach for dialogue management, conversations are interpreted as a sequence of actions to be planned, seeking to consider user's intentions and plans. Modeling dialogue using a plan-based approach assume that the speaker's speech acts are part of a plan. Listeners should then uncover the plan and respond to it in an appropriate manner.

In this scenario, the beliefs would represent not only the information about the world, but also the information about what the agent believes the user wanted to communicate in terms of why he uttered something and what is the reason he did (to make the agent perform an action or to modify the environment). The desires would still represent the states of the world that an agent might like to accomplish: perform an action or answer a question if asked to, for example. The intentions would reflect decisions of an agent about its future actions (just like normal BDI agent architecture). All this cycle encodes communicative intentions of the agent since the agent can now expect user to say something or to do something.

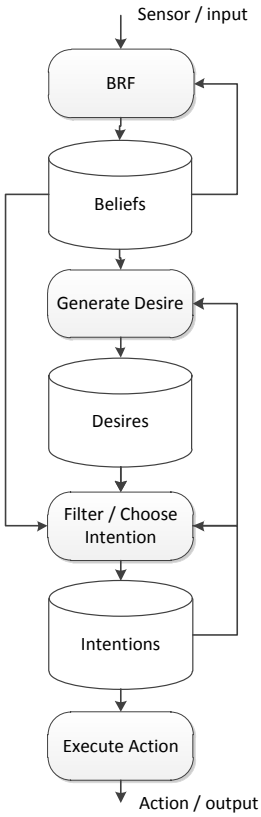

Figure 3.1: General BDI architecture

3.4 Expressive Conversational Language

Before introducing the language used as base for modeling our agent, one must understand the theory in which this language is based. Austin (1962) proposed an action-oriented approach to language and named the actions being performed by speakers during dialogue as **Speech Acts**, claiming that the utterance of any sentence during a real speech situation constitutes three kinds of acts:

- Locutionary act → The utterance of a sentence with a particular meaning. The action of producing an utterance. The meaning expressed by the utterance is its prepositional content.

- Illocutionary act → Ask, answer, promise in uttering a sentence. Actions whose direct consequences are transformations between the speaker and the hearer. The success or failure of an illocutionary act relies on the existence of a "social ceremony" which authorizes the use of the act under some circumstances, giving it the status of a determined action.

- Perlocutionary act → Producing effects in feelings, thoughts, ... in uttering a sentence. Refers to the side effects which the act of producing the utterance is expected to induce on the hearer, provided that the hearer has a sufficient command of the conventional use of the given language and is in the appropriate mental state.

Austin's action-oriented approach for language (in which language was viewed as action rather than as an abstract system for describing reality) led to further investigations from other theorists like (SEARLE 1979). Searle (1979) complemented the work of Austin in many directions trying to characterize speech acts by means of the rules that govern their use. He created a taxonomy of Speech Acts (i.e. utterance types according to some identified features) and identified five basic illocutionary points that are derived from a consideration of the possible relations between one's words and the world. The author claims that all speech acts could be classified according to five classes (transcription from (JURAFSKY; MARTIN 2000)):

- Assertives $\rightarrowtriangle$ Committing the speaker to something's being the case: suggest, put forward, conclude, swear.
- Directives $\rightarrowtriangle$ Attempting to get the addressee to do something: ask, order, beg, request.
- Commissives $\rightarrowtriangle$ Committing the speaker to some future course of action: plan, bet, promise.
- Expressives $\rightarrowtriangle$ Expressing the psychological state of the speaker about a state of affairs: welcome, thank, apologize.
- Declarations $\rightarrowtriangle$ Bringing about a different state of the world via the utterance: "You are fired".

In summary, elementary speech acts are traduced by $F(P)$, where F stands for the illocutionary force with which the act is performed on P (propositional content). The illocutionary force components define conditions which must be observed for the speech act to be performed with success and satisfaction. The six illocutionary force components are (SEARLE; VANDERVEKEN 1985):

- Illocutionary point (Π) $\rightarrowtriangle$ the characteristic aim of each type of speech act (e.g. the characteristic aim of an assertion is to describe how things are).
- Mode of achievement (μ) $\rightarrowtriangle$ special conditions which must be met for a successful utterance of the illocution (e.g special position of authority).
- Degree of strength (t) $\rightarrowtriangle$ amount of force accompanying an utterance (e.g. request and implore both express desires and are identical along the dimensions. However, the latter expresses a stronger desire than the former).
- Propositional content conditions ($\mathcal{P}$) $\rightarrowtriangle$ limitations on what can be said within a given illocutionary force (e.g. one can only promise what is in the future and under his control. One can only apologize for what is under his control and already the case)
- Preparatory conditions (Σ) $\rightarrowtriangle$ conditions that must obtain if the utterance is to be successful (e.g. one cannot marry a couple unless he is legally invested with the authority to do so).
- Sincerity conditions (Ψ) $\rightarrowtriangle$ the expression of a psychological state (e.g. assertion expresses belief; apology expresses regret).

Likewise human actions, illocutionary acts have success conditions considering that they can succeed or not. Illocutionary acts have also satisfaction conditions that must be met in the world of an utterance context for an illocutionary act to be satisfied. Success conditions are conditions that must be observed in the context of utterance for the speaker to perform the speech act. An illocutionary act $F(P)$ is performed with success if and only if the speaker: (i) has achieved the illocutionary point of the force F on the propositional content P with the correct mode of achievement, and P respects all the propositional content conditions of F in this context; (ii) presupposes all the propositions determined by the preparatory conditions of F; (iii) expresses, with the right degree of strength, mental states noted $m(P)$ having the psychological modes m deduced from the sincerity conditions of F. In the same way, an illocutionary act $F(P)$ is satisfied in a context of utterance if and only if P is true considering the right direction of fit of the illocutionary point F. Direction of fit can be:

- From the world to the word $(satis_{wl}^{wd}) \rightarrow$ the world will be (or is being) transformed and will adapt to the propositional content of the message. For example: "Wash the dishes!" - **(comissives and directives)**;
- From the words to the world $(satis_{wd}^{wl}) \rightarrow$ the propositional content corresponds to a fact of the world, independent from the act. For example: "The computer is in my office" - **(assertives)**;
- Double Direction $(satis_{dble}) \rightarrow$ the world is transformed by the act and the sentence represents at the same time an adaptation to the content and a match to a fact of the world. For example: "I declare the session open"- **(declaratives)**;
- No direction of adjustment $(satis_{\varnothing}) \rightarrow$ the propositional content is supposed to be true. Used for expressive acts. For example: "I am glad to live in Brazil"- **(expressives)**.

The proposed taxonomy is an attempt to provide a framework for specifying the actions that can be accomplished with language and the relationship between actions, words, and the mental states of the interlocutors.

The Expressive Conversational Language (BERGER; PESTY 2005; BERGER 2006) is an agent conversational language created to be used in mixed communities of agents[1]. According to the author, traditional ACLs (Agent Communication Languages) used in agent communication typically assume that agents of the system are artificial and that the main objective is knowledge exchange. However, considering MAS involving not only artificial agents, but also humans (mixed communities), then artificial agents require a new conversation language that can enrich their communicational abilities so that they may be able to express their feelings and their attitudes as well as participate in exchanges of ideas and bargaining sessions, for example. The intention is to enable artificial agents within a mixed community to function in a more advanced way that corresponds to the philosophical, psychological and linguistic realities of communication.

[1]Since ECAs are independent agents that can be placed inside multi-agent systems it is important to explain briefly the concept. A multi-agent system (MAS) is a system composed of multiple interacting intelligent agents. Multi-agent systems can be used to solve problems that are difficult or impossible for an individual agent. Agents inside a MAS can share knowledge using agent communication languages and protocols such as KQML and FIPA-ACL. We are not exploring communication inside a MAS in this work and this is why detailed information on ACLs is not explored here. Literature regarding agent communication languages and protocols can be found in MAS papers and books.

Chaib-draa and Vanderveken (CHAIB-DRAA; VANDERVEKEN 1999) proposed a recursive semantics based on success and satisfaction conditions for agent communication languages and proposed the use of situation calculus (MCCARTHY; HAYES 1969) to formalize an adequate reasoning about action and its effects in the world. Situation calculus is originally a first order formalism for action modelization and enables not only the formalization of preconditions and consequences of actions, but represent an efficient tool for action formalization regarding conversations between agents as well. The main elements of the situation calculus are the actions, the fluents, and the situations.

In situation calculus, states of the world (situations) are represented by terms. Performing an action α (accomplishing with success and satisfaction) in a situation s will be noted as $do(\alpha, s)$. The possibility to perform α in a situation s will be formalized by $Poss(\alpha, s)$. The initial situation will be noted $S0$ and the situations will be arranged by the relation $\succ$, where $s' \succ s$ means s' can be achieved from s by performing one or more actions.

Chaib-draa and Vanderveken also proposed a set of binary accessibility relations on situations for an adequation with speech acts theory: $belief(bel(i,p))$, $desire(wish(i,p))$, $goal(goal(i,p))$, $capability(can(i,a,p))$, $commitment(cmt(i,p))$, $has.plan\ (has.plan(i,p))$, $intention(int(i,p))$, $obligation(oblig(i,j,p))$. The definition of such operations allows the express of success and satisfaction conditions for each act type.

The Expressive Conversational Language for Mixed Communities proposes to carry on Chaib-draa and Vanderveken work to reach a formal definition of agent expressive conversation acts. In this language, thirty three expressive conversation acts are formally defined, from the basic acts like inform and request to more expressive ones like promise, suggest and so on.

The selected conversation acts are the following:

- Assertive $\rightarrow$ confirm, deny, think,say, remember, inform and contradict;
- Commissives $\rightarrow$ commit oneself, promise, guarantee, accept, refuse, renounce and give;
- Directives $\rightarrow$ request, ask a question, suggest, advise, require, command and forbid;
- Declaratives $\rightarrow$ declare, approve, withdraw, cancel;
- Expressives $\rightarrow$ thank, apologize, congratulate, compliment, complain, protest, greet.

The conversation acts are defined with their success and satisfaction conditions and explicitly introduce elements from the conversational background. Also, the formalization of the acts include some characteristics:

- Degree of Strength $\rightarrow$ Quantify the amount of insistence with an act is expressed. The degree of strength corresponds to the emphasized number $s = do(says.to(i, j, \langle contradict, p\rangle), s_u, \mathbf{1}, 0)$;
- Role $\rightarrow$ Represents hierarchy. The role corresponds to the emphasized number $s = do(says.to(i, j, \langle contradict, p\rangle), s_u, 1, \mathbf{0})$;

- Direction of adjustment $\rightarrowtriangle$ The direction of adjustment of an illocutionary act can be classified into four categories:

  - From the world to the word $(satis_{wl}^{wd})$ $\rightarrowtriangle$ the world will be (or is being) transformed and will adapt to the propositional content of the message. For example: "Wash the dishes!" - **(comissives and directives)**;
  - From the words to the world $(satis_{wd}^{wl})$ $\rightarrowtriangle$ the propositional content corresponds to a fact of the world, independent from the act. For example: "The computer is in my office" - **(assertives)**;
  - Double Direction $(satis_{dble})$ $\rightarrowtriangle$ the world is transformed by the act and the sentence represents at the same time an adaptation to the content and a match to a fact of the world. For example: "I declare the session open"- **(declaratives)**;
  - No direction of adjustment $(satis_{\varnothing})$ $\rightarrowtriangle$ the propositional content is supposed to be true. Used for expressive acts. For example: "I am glad to live in Brazil"- **(expressives)**.

Amongst those elements that an agent must consider during the analysis and the interpretation of Speech Acts, the degree of strength expressed in the act and the role of the agent are certainly the most important. They are necessary in order to contextualize the interpretation of an act: the degree of strength for quantifying the amount of insistence with which an act is expressed and the role for those interactions whereby a hierarchy is taken into account in the performance of an act.

One example of primitive formalized in the language is presented below. The assertive act *inform* is described as follows: inform is to affirm to someone that a proposition is true presupposing that this person does not know that and having the intention to make this person believe this proposition is, in fact, true:

Value of the components of the illocutionary force: $F = [\Pi], [\mu], [\mathcal{P}], [\Sigma], [\Psi], [t]$

$[\Pi] = \Pi^1$ $\rightarrowtriangle$ correspondent to the illocutionary form of assertion;
$[\mu] = int(i, bel(j, p))[s']$ $\rightarrowtriangle$ the locutor has the intention to make j believe P is true;
$[\Sigma] = bel(i, (\neg bel(j, p)))[s]$ $\rightarrowtriangle$ preparatory condition where i presupposes that j does not know P is true;
$[\Psi] = bel(i, p)[s]$ $\rightarrowtriangle$ sincerety condition where i believes P is true;
The other variables are initialized with $null$.

$$
\begin{aligned}
with & \quad (\forall p)(\forall i, j) \\
s &= do(says.to(i, j, \langle inform, p\rangle), s_u, 2, 0) \\
with & \quad (\forall s')(s' \succ s) \\
s_u &= bel(i, p)[s] \wedge bel(i, (\neg bel(j, p)))[s] \wedge int(i, bel(j, p))[s'] \\
and\ s' &= bel(j, p)[s']
\end{aligned}
$$

The performance conditions will be:

$$\begin{aligned} success(says.to(i,j,\langle inform,p\rangle),s) &\equiv cond.success(\langle inform,p\rangle)[s] \\ satis^{wl}_{wd}(says.to(i,j,\langle inform,p\rangle),s) &\equiv p[s] \wedge p[s_u] \wedge bel(j,p)[s'] \end{aligned}$$

In other words, informing something to someone depends on the preparatory conditions expressed by s_u and will affect upcoming situations (as expressed by s'). In addition, conditions of success (expressed by $success$) have to be verified in the cognitive state of the agent. This means that the act $do(says.to(i,j,\langle inform,p\rangle),s_u,2,0)$ will achieve success only if:

- agent i wants to inform p;
- p is true in the context;
- i presupposes that j ignores p;
- i is sincere and really believes p is true.

Also, this act also have a degree of strength of **2**, meaning that i really believes p is true and has the intention to make j also believe the same. Satisfaction conditions of the act must be checked in upcoming situations. In this case, the act will be satisfied only if p is really true in the situation and if j starts to believe p after the utterance.

Another example of primitive formalized in the language is the expressive primitive *complain*. This primitive represents an example of expression of sentiments and/or attitudes that allows other agents to react accordingly. It should be noted that the locutor do not establish a correspondence between the language and the world, but only react according something that exists in the world.

Value of the components of the illocutionary force: $F = [\Pi],[\mu],[\mathcal{P}],[\Sigma],[\Psi],[t]$

$[\Pi] = \Pi^5 \rightarrow$ correspondent to the expressive illocutionary form;
$[\Sigma] = \neg wish(i,p)[s] \rightarrow i$ finds P undesirable;
$[\Psi] = \neg wish(i,p)[s] \rightarrow i$ is not satisfied with the state of things;
The other variables are initialized with $null$.

$$\begin{aligned} with & \quad (\forall p)(\forall i,j) \\ s &= do(says.to(i,j,\langle complain,p\rangle),s_u,0,0) \\ with & \quad (\forall p')(\forall a)(p \Rightarrow a)(\forall s')(s' \succ s) \\ s_u &= \neg wish(i,p)[s] \\ and\ s' &= \phi \end{aligned}$$

The performance conditions will be:

$$
\begin{aligned}
success(says.to(i, j, \langle complain, p\rangle), s) &\equiv \\
cond.success(\langle complain, p\rangle) &\ [s] \\
satis_{\phi}(says.to(i, j, \langle complain, p\rangle), s) &\equiv \\
success(says.to(i, j, \langle complain, p\rangle), s) &\supset \\
m(i, p)[do(says.to(i, j, \langle complain, p\rangle) &\quad , \quad s_u)]
\end{aligned}
$$

The expressive conversation act **complain** indicates a state of affairs whereby the (true) proposition p is undesirable for i in an **affective** sense, expressed by zero direction of fit. The conditions of success and satisfaction for expressive conversation acts have the same role as other types of acts. However, to satisfy an expressive act, the agent must, in the situation of utterance, express the attitudes signified by the symbol representing the modality: m (e.g. the agent will have to act in order to express the according mental state).

It is important to remember that an artificial agent is unable to lie, but a human agent can lie and his artificial agent partner will have no way of knowing this unless it has prior information. Therefore, it is assumed (in this formalization) that human agents will be sincere when dealing with artificial agents.

3.4.1 Using the Language to Model Conversational BDI Agents

This section will describe how this conversational language can be used to implement a conversational agent using BDI approach. In order to do that, we are using one example of the relation between the language and real dialogue that is given by the authors (it was extracted from a corpus of the Grenoble tourism office). The example shows a conversation between a client (C) and an employee (E) and it is only theoretical (according to the authors no real agent was modeled to perform this dialogue). In the example both agents are considered as having the same hierarchy. We use this example to explain how an agent could be modeled using a BDI approach.

1. E: Good morning
2. C: Good morning. I would like a map of Grenoble.
3. E: Sure.

In line 1, the speech act is *greet* (see the formalization below). Since both conversational partners are assumed to be sincere, the greeting will be associated with corresponding attitudes that will reflect emotional and behavioral attitudes of the agent (this emotional and behavioral attitudes would depend on other important factors like the internal emotional model, for example). Greet has no specific satisfaction conditions and therefore no specific act in response will be expected mainly because *greet* has no propositional content. When one greets someone, for example, by saying "Hello", one indicates recognition in a courteous fashion. Common sense expect us to respond when greeted but this response is not mandatory for conversation to keep flowing. Regarding BDI approach,

one could imagine that the agent client would be programmed with the plan of greeting everyone in conversation at every new encounter, for example.

$$
\begin{aligned}
with & \quad (\forall i, j) \\
s &= do(says.to(i, j, \langle greet, p\rangle), s_u, 0, 0) \\
with & \quad (\forall s')(s' \succ s) \\
s_u &= \phi \\
and\ s' &= \phi
\end{aligned}
$$

The performance conditions will be:

$$
\begin{aligned}
success(says.to(i, j, \langle greet, p\rangle), s) &\equiv cond.success(\langle greet, p\rangle)[s] \\
satis_{\phi}(says.to(i, j, \langle greet, p\rangle), s) &\equiv \\
success(says.to(i, j, \langle greet, p\rangle), s) &\supset m(i, p)[do(says.to(i, j, \langle greet\rangle), S_u)]
\end{aligned}
$$

Line 2 shows the response of the client and includes not only a greeting back (working just as explained above), but also a *request* (see formalization below). A request is a directive illocution that allows for the possibility of refusal. A request can be granted or refused by the hearer. In this case, we can consider p as plan of Grenoble. The client is expecting the employee to give him a map of Grenoble. This expectation is now something that will influence upcoming communication and the attitudes of both hearer and speaker. By this time, the hearer knows that the client wants a map and is expecting to receive one. A BDI employee agent would have to consider this request and update the belief base with specific request. Later, he would have to reason to find a plan to deal with the situation. In addition, since he is greeting back, it is obvious to assume that this agent should be programmed to react to a new perception in the environment (considering talking as events in an environment) and, consequently, a new belief representing that someone just interacted with him by greeting.

$$
\begin{aligned}
with & \quad (\forall p)(\forall i, j) \\
s &= do(says.to(i, j, \langle request, p\rangle), s_u, 0, 0) \\
with & \quad (\forall p')(\forall a)(p \Rightarrow a)(\forall s')(s' \succ s) \\
s_u &= bel(i, can(j, a, p')[s] \wedge bel(i, Poss(j, a)) \\
& \quad \wedge wish(i, do(j, a))[s'] \wedge \neg oblig(j, i, a)[s'] \\
and\ s' &= a[s'] \wedge p[s']
\end{aligned}
$$

The performance conditions will be:

$$
\begin{aligned}
success(says.to(i,j,\langle request,p\rangle),s) &\equiv cond.success(\langle request,p\rangle)[s] \\
satis^{wd}_{wl}(says.to(i,j,\langle request,p\rangle),s) &\equiv (\exists s',s'')(s'' \succ s' \succ s)Poss(a,s'),...,Poss(a,s'') \wedge \\
success(says.to(i,j,\langle request,p\rangle),s) &\supset p[do(a,do(a,do(a,s''))))]
\end{aligned}
$$

Line 3 shows that the employee is accepting the request (see formalization of accept below). The most natural way to treat acceptances is as commissives which are responses to certain very restricted classes of directives and commissives, and where the propositional content of the acceptance is determined by the speech act to which is a response. Thus if one receives an offer, invitation, or application one can accept or reject it, and in each case the acceptance commits the speaker in certain ways. For example, if you offer to sell me your house for $100.000 and I accept, I am committed to buying your house for that amount. In the example, the client is requesting a map and the employee is accepting the request. The employee then is committed to giving the user a map. In a BDI approach, giving the client a map would be the chosen plan to be executed.

$$
\begin{aligned}
with & \quad (\forall p)(\forall i,j) \\
s &= do(says.to(i,j,\langle accept,p\rangle),s_u,0,0) \\
with & \quad (\forall a)(p \Rightarrow a)(\forall s',s'')(s' \succ s \succ s'') \\
s_u &= bel(i,p)[s] \wedge bel(i,Poss(i,a))[s] \wedge \\
& \quad int(i,do(i,a))[s'] \wedge int(j,do(i,a))[s''] \\
and\ s' &= p[s] \wedge a[s'] \wedge p[s']
\end{aligned}
$$

The performance conditions will be:

$$
\begin{aligned}
success(says.to(i,j,\langle accept,p\rangle),s) &\equiv cond.success(\langle accept,p\rangle)[s] \\
satis^{wd}_{wl}(says.to(i,j,\langle accept,p\rangle),s) &\equiv (\exists s',s'')(s'' \succ s' \succ s)Poss(a,s'),...,Poss(a,s'') \wedge \\
success(says.to(i,j,\langle accept,p\rangle),s) &\supset p[do(a,do(a,do(a,s''))] \wedge p[s] \wedge p[s']
\end{aligned}
$$

3.5 Final Considerations

The purpose of this chapter was to discuss about the characteristics of human communication, focusing on dialogue. The chapter highlighted the importance of conversation

as an activity where participants engage together. In a dialogue, actions of one participant are dependent of the actions of the other. When someone says something, the expectation is that the utterance will be heard, understood, and (most importantly) acted upon by the other participant.

Likewise chapter 2, the discussion and literature presented in this chapter is not intended to be exhaustive but to help the reader to understand our approach for modeling dialogue in our agent. We are combining a plan-based BDI dialogue modeling approach together with the thirty three expressive conversation acts from the Expressive Conversational Language in order to enhance affective communication in ECAs.

The upcoming chapters will describe our work. Chapter 4 will present our model defining hidden conversational goals in communication according to specific personality facets. Chapter 5 will explain how we are applying our proposed model using the expressive conversation language and a BDI approach for dialogue model and management.

4 A MODEL OF PERSONALITY-BASED HIDDEN CONVERSATIONAL GOALS

As explained in the introduction of this document, we are interested in increasing believability of ECAs, specifically considering the second class of believability problems: making the intentionality of the agent believable regarding actions and reactions that create the impression of an independent entity with goals and, specially, feelings. This chapter will present our approach to do so: the definition of hidden conversational goals in communication according to personality facets.

Because we are dealing with ECAs and have to consider all the challenges of the field, we follow the taxonomy of relevant design aspects of ECAs to describe our model. We start by contextualizing the applicability of the agent (section 4.1). After we focus on mental aspects of the agent, which is where our model is, in fact, inserted. We describe our model (section 4.2) in detail. The model explains how personality will influence discourse capabilities of the agent.

4.1 Applicability: SUDOKU puzzle Game

A Sudoku puzzle is a a logic-based, combinatorial number-placement puzzle. It is played on a flat grid (figure 4.1) that typically contains 81 cells (nine rows and nine columns) and is divided into nine smaller squares containing nine cells each (subgrids or regions composed of three rows and three columns).

5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

5	3	**4**	**6**	7	**8**	**9**	**1**	**2**
6	**7**	**2**	1	9	5	**3**	**4**	**8**
1	9	8	**3**	**4**	**2**	**5**	6	**7**
8	**5**	**9**	**7**	6	**1**	**4**	**2**	3
4	**2**	**6**	8	**5**	3	**7**	**9**	1
7	**1**	**3**	**9**	2	**4**	**8**	**5**	6
9	6	**1**	**5**	**3**	**7**	2	8	**4**
2	**8**	**7**	4	1	9	**6**	**3**	5
3	**4**	**5**	**2**	8	**6**	**1**	7	9

Figure 4.1: A sample SUDOKU puzzle and its solution

The objective is to fill a grid with digits so that each row, column or region that compose the grid contains all of the digits from 1 to 9 (in such a way that no digit appears twice in the same row, column or region). The puzzle setter provides a partially completed grid, which typically has a unique solution (DELAHAYE 2006).

Sudoku puzzles, and their variants, have become extremely popular in the last decade, and can now be found daily in most major newspapers. Solving Sudoku puzzles by hand is generally done through elimination strategies that keep track of what numbers are available to be placed in each square of the grid, and updating these by eliminating indices that cannot be allowed in a square based on some line of reasoning (PROVAN 2008).

Sudoku still presents mathematicians and computer scientists with a variety of challenging issues ranging from best strategies to solve the game to estimation of how many Sudoku grid possibilities can exist. Next sections will discuss why we chose a sudoku game as an application scenario for our work.

4.1.1 Why choosing a SUDOKU game?

Inside PRAIA project, a platform was defined in order to test and validate the research developed inside the scope of the project. This platform consists of a collaborative game, called collaborative sudoku. The collaborative SUDOKU is a multi-user version of the popular logic-based number placement puzzle described earlier. In the developed collaborative version of the game, a team collaborates through a web-based interface. Supported by a game server, the partners interact, negotiating and coordinating actions in order to construct a shared solution to each proposed reasoning problem. The main goal of each team is to complete the task faster than the adversary team, matched by the server at random choice.

This platform was created with specific intentions of testing emotional models of users inside a collaborative educational game. It was designed with the purpose to study empirically what happens in terms of peer-related emotions when this kind of simple reasoning task is addressed collaboratively. It was specifically designed to test a model that aimed to recognize the specific emotions students feel towards their peers during collaboration. More information on this platform and emotional model can be found in (JAQUES et al. 2009).

Since our intention in this work is to study *"How to respond appropriately to student's emotions?"* we decided to investigate the field of ECAs as an alternative and to use this kind of agent in a different perspective considering previous work of the group. Thus, considering our focus research and perspective, the collaborative sudoku game was not chosen as a scenario because the user would probably be distracted by the competition and the collaboration and would not give much importance to the presence of the agent. Instead, we redesigned and completely recreated the whole platform to fit our expectations. The collaboration and the competition were taken out of the game so the ECA could serve as a companion while playing, aiming to explore the possibilities of dialogue without the influence of other control variables. Next section will explain the redesigned platform.

4.1.2 The SUDOKU Platform

The new platform architecture is shown in figure 4.2. Different from the PRAIA project original platform, the new platform takes out the competition factor and introduces an agent to interact with users while they play SUDOKU game. The agent inside the platform is implemented using Jason and AgentSpeak(L) (more details about Jason

framework and AgentSpeak(L) language will be given in next chapter). The interface is implemented using Google Web Toolkit (GWT). GWT is a development toolkit for building and optimizing complex browser-based applications [1]. Server-side game handling functions and communication between interface and Jason framework were implemented using Java. Java is a general-purpose, concurrent, class-based, object-oriented programming language [2]. The physical appearance of the agent inside the platform as well as the non-verbal communication possibilities used DIVA toolkit (more details will be presented in next chapter).

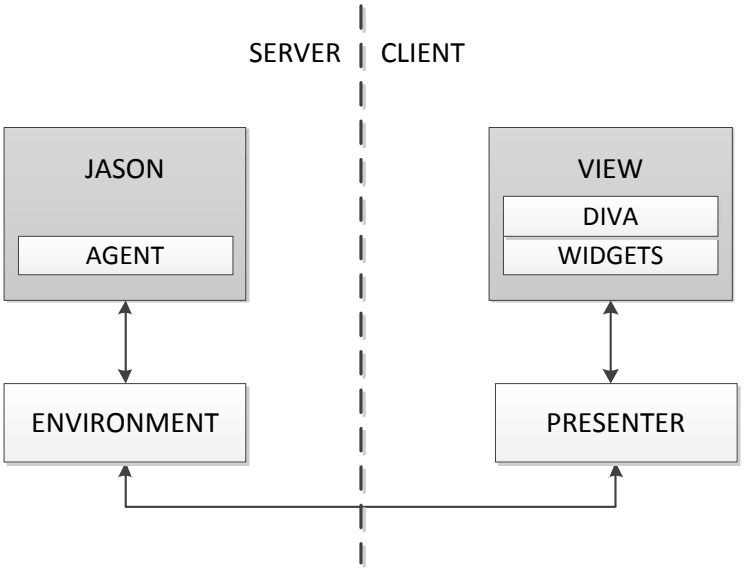

Figure 4.2: Architecture of the New SUDOKU Platform

In the new platform, users are able to interact with the board game by making a move (placing a number in a cell, deleting a number from a cell, replacing a number in a cell), asking for feedback (clicking the check button), and starting over (clicking the clear button). Also, users are able to communicate with the agent by selecting a sentence and clicking send button. The conversation between the agent and the user is shown in the interface. Figure 4.3 shows the interface of the new game platform.

We defined three different tasks to be accomplished by the agent that interacts with the user while playing SUDOKU:

- Presentation $\rightarrow$ This task involves the presentation of the agent and the game (subtasks include presentation of the agent, presentation of the game, presentation of the interface, and loading a game). The influence of personality in this task can vary from the amount of detail given to the amount of interaction with the user (more details will be given in next chapter).

- Observation $\rightarrow$ In this task, the agent observes the user while he plays and interferes or not according to its beliefs and personality traits. The agent can just observe without interference or he can criticize or suggest some other action (for example:

[1] More information in http://code.google.com/webtoolkit/
[2] More information in http://www.oracle.com/us/technologies/java/index.html

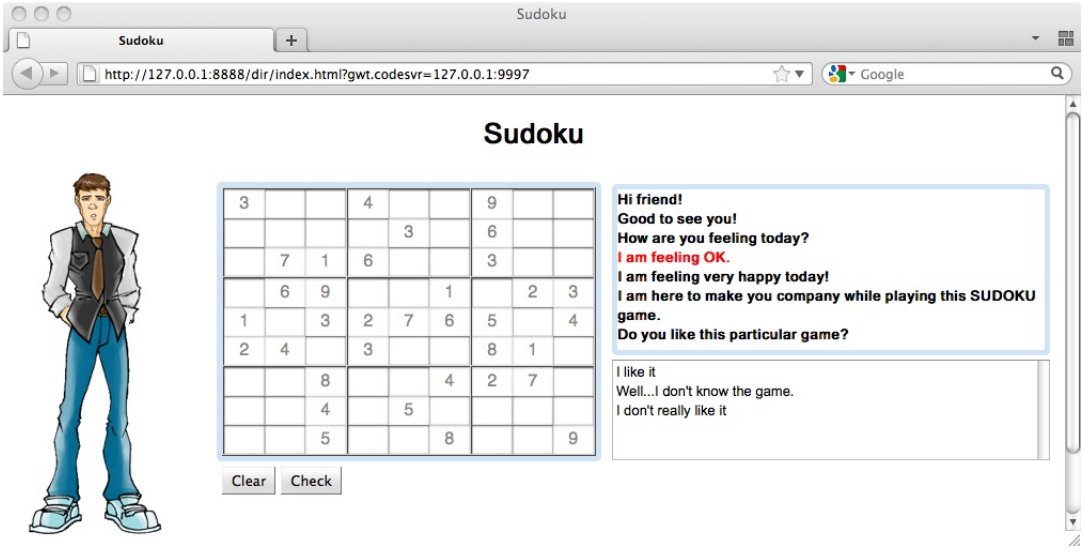

Figure 4.3: The game platform

inform about a wrong move or express happiness when a right move is made). In our specific scenario, the second task is repeated until the game is solved (i.e. for each move of the user the agent will observe and then provide some kind of feedback).

- Discussion → This task provides opportunity for discussion about the game. This discussion is important because of the possibility of expressing emotion using expressive acts. Emotional feedback will occur in tasks 1 and 2, but this particular task is set to convey emotional feedback.

The choice of these tasks is based on the fact that they represent three distinct situations usually experienced by humans when communicating. In addition, these tasks can easily be adapted to other scenarios (one example could be a student solving a math problem where the first task of the agent would be explaining the problem and strategies that could be used to solve the math problem, observing the student performing the solution, and discussing the solution).

4.1.3 Platform Events

According to the Oxford Advanced Learner's dictionary (HORNBY 1995) an event is a thing that happens, especially something important. In our game scenario, agent events are restricted to the exchange of messages and displays of attitudes (they will not have the ability to place numbers in the board). User events, on the other hand, are classified by their interaction type: action events, time events, and communication events. Action events involve the moves of the user in the game board (placing or deleting a number in any cell of the board), asking for feedback (clicking the check button), and starting over (clicking the clear button). Communicative events involve the exchange of messages. Time events relate to the perceived time without any other kind of events in interface.

Figure 4.4 illustrates the perceived user events in the scenario. Each of the big boxes represent one task of the agent. Subtasks are shown in the left column (column 1), the type of events are shown in the middle (column 2), and the description of events are shown in the right column (column 3). In task one (presentation) the agent can only perceive

communicative and time events since the game will only be loaded after all presentation is done. All action events will be ignored. In task two (observation) all the possible events will be available (action, time, and communicative events). In task three the game will be finished and action events will be also ignored.

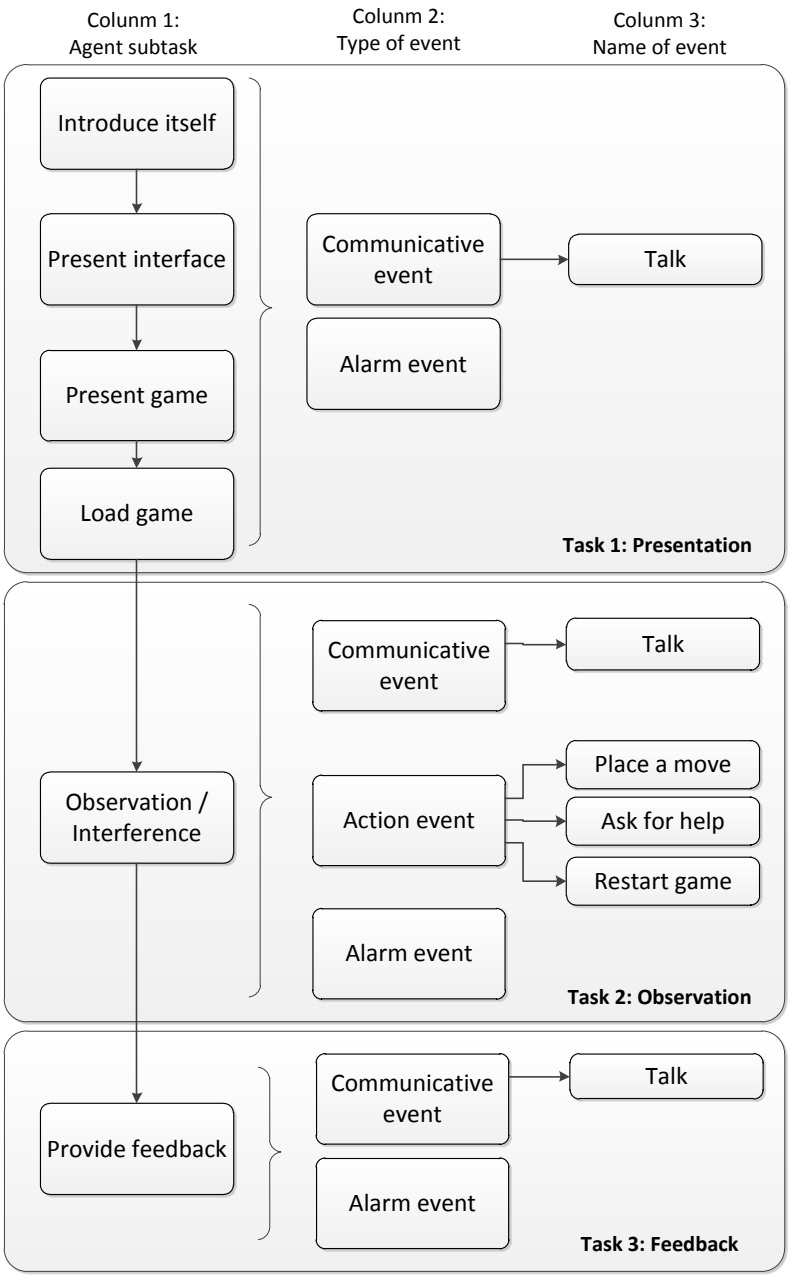

Figure 4.4: User perceived events

One could argue that asking for help by clicking the check button is the same as asking for help by sending a message. The difference, in our case, is that asking for help can be done anytime regardless of what was the last conversational interaction between user and agent. The perception of both kinds of events can help verify if the user is enjoying conversation or is just interested in playing.

4.2 The Model

Chapter 3 discussed that modeling dialogue using a plan-based approach assumes that the speaker's speech acts are part of a plan and that listeners should uncover the plan and respond to it in an appropriate manner. Considering this notion of goals in communication, we propose to define a model using the notion of conversational goals that we believe are present in communication. We call these goals *"hidden conversational goals"* (HCG).

Other works in literature exploring the relation between personality and behavior in user affect (ZHOU; CONATI 2003; CONATI; MACLAREN 2009) use experimentation with people to create models of users behavior in interaction (usually based on a very specific scenario). Our work use literature as a base for defining the HCG since we assume that these goals are not easily perceived by people in daily communication (i.e. people don't think about these goals in an explicit way). People are usually influenced by the communicative intents related to the particular tasks they want to accomplish or the situation they are involved in and do not realize that verbal behavior can be influenced by personality facets in a long-term conversation. Due to this fact, performing experiments trying to define hidden conversational goals in general dialogue would be a hard task with multiple variables to be considered. Instead, we are creating a model based on literature and performing experiments to see if this notion is, in fact, perceptible by users interacting with our agent (validation experiments will be described in chapter 6).

In order to explain our model, we first need to contextualize and explain the grounding personality model we are considering in this thesis (section 4.2.1). After, we will explain how we are relating personality facets and verbal behaviors of agents (section 4.2.2).

4.2.1 The Five-factor Personality Dimensions and NEO PI-R Facets of Personality

Trait-based approaches to personality focus on the conceptualization that individuals differ from one another in a small number of dimensions that remain stable over time and across situations. Traits can be defined as dimensions of individual differences in tendencies to show consistent patterns of thoughts, feelings, and behaviors that allow the characterization of human beings. (SALGADO 2004; CAMPOS; KELTNER; TAPIAS 2004; MESQUITA; HAIRE 2004)

The five-factor model (FFM) of personality proposes that there are five basic dimensions of personality known as OCEAN: Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism (JOHN; SRIVASTAVA 1999; MCCRAE; COSTA 1987; GOLDBERG 1990). Table 4.1 shows some of the positive and negative adjectives that have been associated with each of the personality dimensions.

- Openness to Experience ⇸ Openness to Experience relates to interest in experience in a variety of areas. Open individuals usually have a particularly fluid style of consciousness characterized by easily making remote associations. They are reported to be are creative and adaptable instead of pragmatic and down-to-earth. Moreover, they are reported to be imaginative responsive to art and beauty, attentive to their own feelings, willing to try new activities, intellectually curious, and unconventional. Closed individuals, on the other hand, are more comfortable with the world they know and tend to compartmentalize their ideas and feelings (MCCRAE 2004a).

- Conscientiousness ⇸ Conscientiousness is the dimension of personality that con-

Table 4.1: Illustrative Positive and Negative Adjectives for each Dimension of Personality

Dimension	Positive Adjectives	Negative Adjectives
Agreeableness	Sympathetic, cooperative considerate warm, tactful	Cold, rude, unkind
Consciousness	Responsible organized, systematic, hardworking, neat	Inefficient, impulsive, irresponsible, careless, sloppy
Extroversion	Extroverted, talkative, assertive, gregarious	Reserved, introverted, quiet, shy
Neuroticism	Unenvious, relaxed, calm, stable	Moody, nervous, insecure
Openness to Experience	Creative, artistic, imaginative, curious	Unimaginative, conventional, literal-minded

trasts people who are methodical, purposeful, and deliberate with those who are disorganized, lazy, and hasty. High levels are associated with academic achievement, superior job performance, and accomplishment of tasks (MCCRAE 2004b).

- Extroversion ⇀ Extroversion contrasts qualities such as sociability, assertiveness, and enthusiasm with qualities such as social reserve, quietness, and thoughtfulness. Literature report that extraverts report experiencing more positive emotions, whereas introverts tend to be closer to neutral, suggesting correlation between extroversion and happiness. Also, while extroverts tend to report higher levels of self-esteem, introverts tend to be more vulnerable to stress symptoms (MATTHEWS 2004).

- Agreeableness ⇀ Agreeableness describes a class of individual differences that generally have to do with being positive in relations with others. In other words, it is a trait used to describe differences in being predominantly social (positive social orientation) versus antisocial or self-oriented in social interactions (SHEESE; GRAZIANO 2004). Considering group interactions, agreeableness relates in a negative way with competitiveness, suggesting that agreeableness contributes to group cohesion and protects against group dissolution. According to the authors, more agreeable individuals appear to behave in ways that are constructive rather than destructive to their relationships with others, suggesting a positive relation to relationship quality (e.g., fewer conflicts, more satisfaction) and quantity (e.g., more friends).

- Neuroticism → Neuroticism is the dimension of personality enduring tendency to experience negative emotional states (e.g. anxiety, anger, guilt, and depression). Individuals with high neuroticism scores are more likely to interpret ordinary situations as threatening, and minor frustrations as hopelessly difficult. This personality trait is also associated with low emotional intelligence, which involves emotional regulation, motivation, and interpersonal skills. (PETERSON; PARK 2004).

It is important to mention that scoring high or low in one dimension does not necessarily influence the scores of other traits. One example is the combination of high scores in traits like neuroticism and extroversion. In this case, the neurotic extrovert individuals would experience high levels of both positive and negative emotional states, a kind of "emotional roller coaster". (PETERSON; PARK 2004).

The NEO PI-R (Neuroticism Extraversion Openess Personality Inventory Revisited) measures six subordinate facets of each of the "FFM" personality factors (COSTA; MCCRAE 1992). Figure 4.5 shows facets of personality according to each dimension of the FFM.

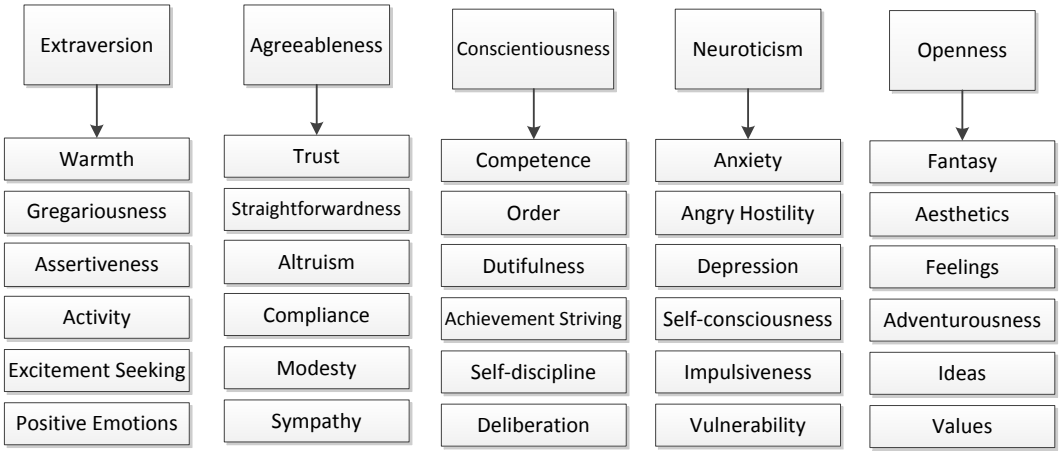

Figure 4.5: The NEO PI-R Facets of Personality

This model represents a more detailed view of personality and is commonly used to measure the interpersonal, motivational, emotional, and attitudinal styles of people. Abilities of problem-solving, decision-making, or style of relating to others can be measured by a combination of some specific facets in more than one trait. A brief description of each personality factor (according to the model) is given below:

- Extraversion
  - Warmth/Friedliness → People that are friendly genuinely like other people and openly demonstrate positive feelings toward others. Also, they tend to make friends quickly and they easily form close and intimate relations. Low scores on this facet are perceived as distant and reserved.
  - Gregariousness → People with high scores on this facet find the company of others pleasant, rewarding, and stimulating. They enjoy crowds because of

its excitment. On the other hand, low scores tend to feel overwhelmed by crowds. Although they do not necessarily dislike being with other people, they sure need privacy and time to themselves.

  - Assertiveness ⇒ High scores on assertiveness like to take charge and direct activities of others, tending to be leaders in groups. Low scores don't talk much and don't bother not being in control.
  - Activity ⇒ People with high scores on this facet move quickly and energetically and tend to live fast-paced and busy lives.
  - Excitement Seeking ⇒ High scores on this facet need high levels of stimulation. They are seen as likely to take risks.
  - Cheerfulness/Positive Emotions ⇒ People with high scores on cheerfulness tend to experience a range of positive feelings (enthusiasm, optimism, happiness).

- Agreeableness
  - Trust ⇒ People with this facet assumes that most people are fair and have good intentions. Low scorers tend to see other people as selfish and potentially dangerous.
  - Straightforwardness/Morality ⇒ High scorers are frank and sincere when dealing with others. They don't see the need for pretense and manipulation. Low scorers are more guarded and do not open reveal the whole truth.
  - Altruism ⇒ People with high score on this facet find helping others rewarding and are willing to assist people who are in need.
  - Compliance/Cooperation ⇒ High scorers dislike confrontations and are willing to compromise or deny their own needs in order to get along with others.
  - Modesty ⇒ People scoring high on this facet do not like to claim that they are better than other people.
  - Sympathy ⇒ High scorers are compassionate. They feel the pain of others and are easily moved to pity. Low scorers, on the other hand, tend to make objective judgments based on reason.

- Conscientiousness
  - Competence ⇒ When dealing with a task or trying to achieve success, high scorers tend to believe they have the intelligence and self-control necessary.
  - Order ⇒ High scorers tend to be well-organized and like to live according to routines and schedules.
  - Dutifulness ⇒ People with high scores on this facet have a strong sense of moral obligation.
  - Achievement Striving ⇒ Individuals scoring high on this facet tend to have a strong sense of direction in life and they strive hard to acieve excellence.
  - Self-discipline ⇒ High scorers tend to persist while facing difficulties tasks. They can stay on track despite distractions.

  - Deliberation ⇀ Individuals scoring high on this facet usually take time when facing decisions. They tend to think before acting.

- Neuroticism

  - Anxiety ⇀ High scorers tend to be generally fearful and often feel like something dangerous is about to happen.
  - Angry Hostility ⇀ Individuals scoring high on this facet tend to be resentful when they feel cheated and enraged when things do not go their way.
  - Depression ⇀ High scorers have difficult initiating activities, presenting a tendency to feel sad or discouraged.
  - Self-consciousness ⇀ People with high scores on this facet are sensitive about what others think of them and are afraid of criticism. They tend to feel judged all the time.
  - Impulsiveness ⇀ People scoring high on this facet are oriented toward short term rewards. They have strong urges and cravings.
  - Vulnerability ⇀ Under stress, people scoring high on this facet tend to experience panic and confusion.

- Openness to Experience

  - Fantasy ⇀ Individuals scoring high on this facet tend to be imaginative and to use fantasy as a way to escape from an ordinary world.
  - Aesthetics ⇀ High scorers love beauty and arts.
  - Feelings ⇀ People in this scale are awareness of their own feelings. They tend to express emotions openly.
  - Adventurousness ⇀ Individuals scoring high on this facet are eager to try new activities. They find familiarity and routine boring.
  - Ideas ⇀ High scorers are open-minded to new and unusual ideas and tend to enjoy puzzles and riddles. In contrast, low scorers prefer to deal with people rather than ideas.
  - Values ⇀ high scorers are willing to challenge authority and traditional values while low scorers prefer security and stability brought by conforming to tradition.

4.2.2 Emotion as a Way of Relating Personality and Hidden Conversational Goals

The five-factor model of personality proposes that there are five basic dimensions of personality: Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism. However, the description of the five dimensions can be considered too broad since there are other models that offer a more specific view on personality that are used to measure the interpersonal, motivational, emotional, and attitudinal styles of people. Due to this fact, we have decided to adopt the NEO PI-R facets of personality as the grounding personality model for our agent.

Since the NEO PI-R model measures six subordinate facets of each of the FFM personality dimensions (representing a total of 30 different facets that could be explored),

we have chosen to explore only one or two facets of each dimension. The choice of these specific facets took into consideration the fact that they represent the ones that could best be explored in a puzzle game scenario:

- Extroversion ⇀ Warmth.
- Agreeableness ⇀ Altruism.
- Conscientiousness ⇀ Competence and Deliberation.
- Neuroticism ⇀ Self-consciousness.
- Openness to Experience ⇀ Feelings.

Since emotions and personality are both affective phenomena that should be taken into consideration when designing ECAs, we decided to use a grounding model of emotions to define our hidden conversational goals in communication according to each specific personality facet. The grounding emotional model used for this work is the OCC (Ortony, Clore, and Collins) model (ORTONY; CLORE; COLLINS 1988). This model (figure 4.6) is used in this thesis because it represents a simplified version of human's emotions. In addition, several works in literature can be found applying the model to pedagogical and conversational agents (EGGES; KSHIRSAGAR; THALMANN 2003; BARTNECK 2002; ZHOU; CONATI 2003; CONATI; MACLAREN 2009; JAQUES; VICARI 2007).

The OCC model (ORTONY; CLORE; COLLINS 1988) is a model of cognitive appraisal for emotions, meaning, a model describing the reasoning process involving many types of emotions. In this model, it is assumed that emotions arise from valenced (positive or negative) reactions to situations like events (way people perceive things that happen), agents (people, biological animals), and objects. Following the model, there are distinct types of emotion, meaning, distinct kinds of emotion that can be realized in a variety of forms and that can be differentiated by intensity (fear can have intensities of concern, frightened, petrified). Also, the model groups emotions according to their eliciting conditions. The authors believe that this model (when implemented in a machine) can help to understand what emotions people experience under what conditions.

In our work, we are focusing on emotions of *hope* or *fear* and in the event of a player coming to the environment (i.e. start using the system). We believe these feelings can help determining hidden conversational goals in verbal communication.

Extroverts with high scores on the warmth facet demonstrate positive feelings and tend to make friends quickly, forming close and intimate relations. Also, they are described as constantly demonstrating positive feelings toward others to reinforce positive interactions. Therefore we can assume that an extroverted warm person will have the emotion of *hope* of establishing a friendship with others (or the *fear* of being ignored by others in terms of trying to establish a friendship). Due to this fact, they will have the hidden conversational goal of establishing a friendship (trying to confirm their hope and to let go of their fear). 4.7 illustrates this example.

In our specific scenario, an extroverted warm agent will tend to demonstrate interest in other's life and preferences trying to identify common bonding factors and gain truth. He will start performing his predefined tasks (according to his applicability scenario) but will also keep asking questions in order to learn more about the user. He will try to communicate as much as possible by suggesting moves or tactics in the game and also by using expressive acts to demonstrate positive feelings toward the other participant. In the

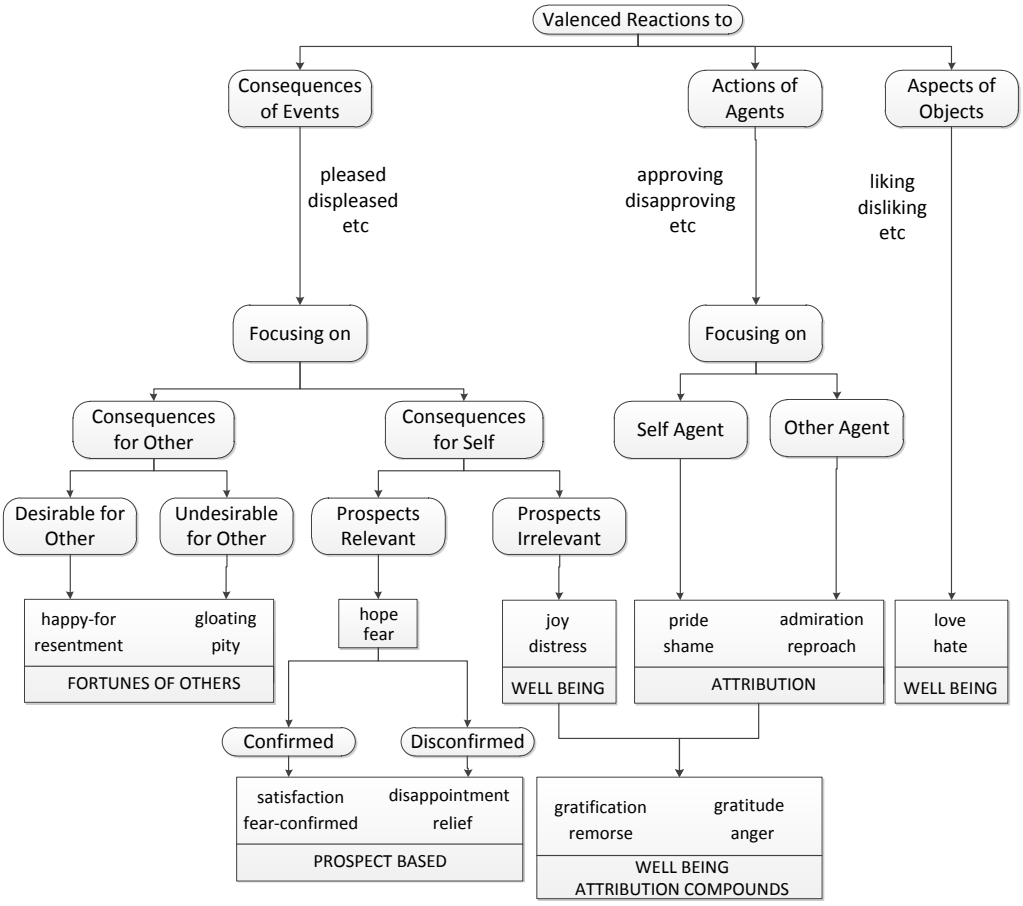

Figure 4.6: OCC Model
(ORTONY; CLORE; COLLINS 1988)

observation task, he will make comments on the user moves and will keep positive about the whole situation (even if disappointed).

Agreeable people with high scores on altruism are described as willing to assist people who are in need. Considering this literature definition, an agreeable altruist will have the emotion of *hope* of helping others and feeling useful (or the *fear* of being ignored by others in terms of providing help and being useful). Figure 4.8 illustrates this situation. We can assume, consequently, that agreeableness people with high scores on altruism have the hidden conversational goal of helping and feeling needed. Because of this characteristic, they will tend to help even if not requested to. Also, they will tend to demonstrate positive emotions when helping people.

In our scenario, an agreeable altruist agent will not only perform his predefined tasks but will also keep offering help. While presenting the game, he will give more details than other personality facet agents and will demonstrate positive feelings when the other participant demonstrates appreciation for help.

Conscientious individuals with high scores on competence and deliberation are described as self-confident and careful when acting. A conscientiousness (competence/deliberative) person, when talking to other people in a collaborative way, will have the emotion of *hope* of being trusted in his advices (or the *fear* of being too intrusive and having his advices ignored). Figure 4.9 illustrates this situation. They will have the hid-

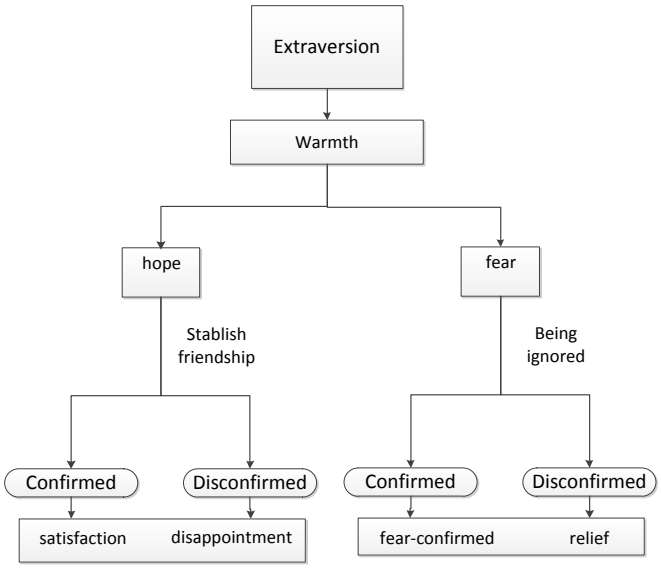

Figure 4.7: Hopes and Fears of a Warmth Facet of an Extroverted Personality (ORTONY; CLORE; COLLINS 1988)

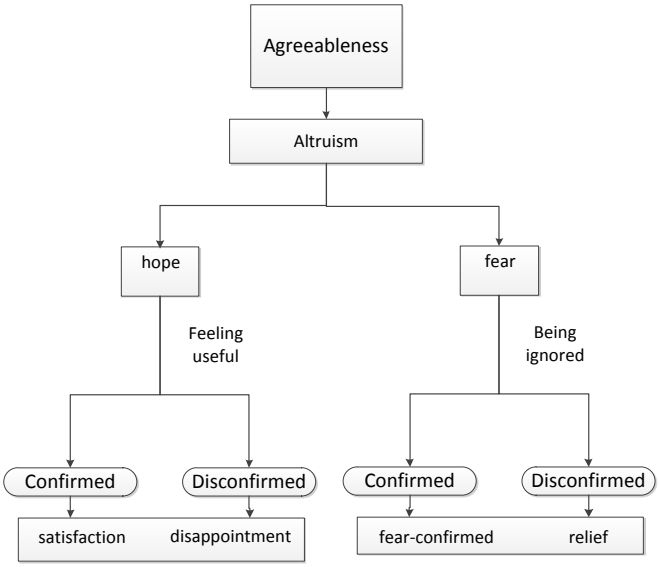

Figure 4.8: Hopes and Fears of an Altruist Facet of an Agreeableness Personality (ORTONY; CLORE; COLLINS 1988)

den conversational goal of stimulating the partner to think before act and also to empower confidence of the other participant.

In our scenario, a conscientious deliberative/competence agent will keep stimulating the user to be careful when making a move. Also, they will keep telling the user he is capable of achieving success no matter what circumstances.

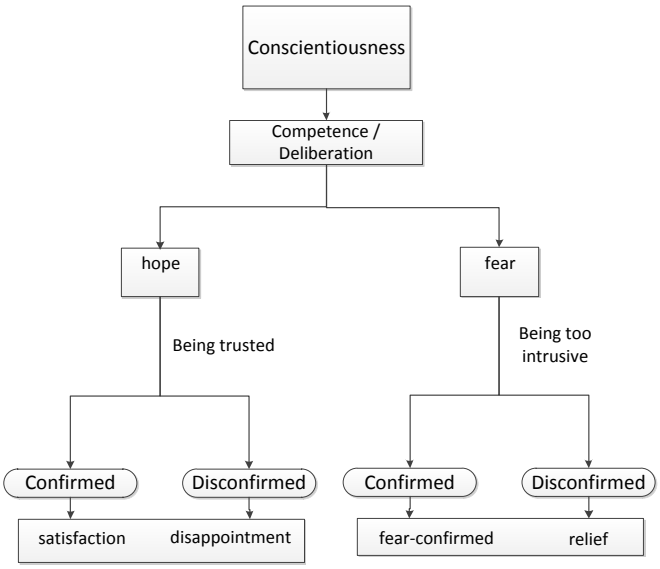

Figure 4.9: Hopes and Fears of a Competence/Deliberation Facet of a Conscientiousness Personality

(ORTONY; CLORE; COLLINS 1988)

Neurotic persons with high self-consciousness are presented as sensitive of other's opinions and afraid of criticism. Therefore, in conversation, the hidden goal is to justify or avoid possible errors or bad attitudes (since they feel they are constantly judged) and to demonstrate the emotional feelings when criticized. This is due to the fact that they can be seen as having the emotion of *fear* of being judged or the *hope* of performing well in order not to be judged (figure 4.10).

In our scenario, a neurotic self-conscious agent will constantly complain about the difficulty of the game trying to justify wrong moves and will be defensive when feeling judged.

Finally, open individuals with high scores on feelings are described as having the tendency to be aware of their feelings and to demonstrate emotions openly. They will have the emotion of *hope* of demonstrating their feelings openly and the *hope* of being misunderstood (because they were not open enough). Figure 4.11 illustrates the *hopes* and *fears* that will be experienced by an open agent with high scores on feelings. Due to this fact, we can assume that they will have the hidden conversational goal of expressing themselves emotionally.

The use *hopes* and *fears* to model personality based hidden conversational goals help designers to create agents able to keep long-term relationships with users. Hidden conversational goals enable an adaptation according to the tasks being performed and the memory of the agent. Moreover, adaptations would not cause great changes in manifested agent verbal attitudes (example: in this specific work we are not modeling agents with memory about older interactions with same users but we can easily understand that instead of establishing friendship, a extroverted warmth agent could have the hidden conversational goal of maintaining friendship - and yet, the verbal behavior would remain unaltered - the agent would still demonstrate interest in other's life by asking questions

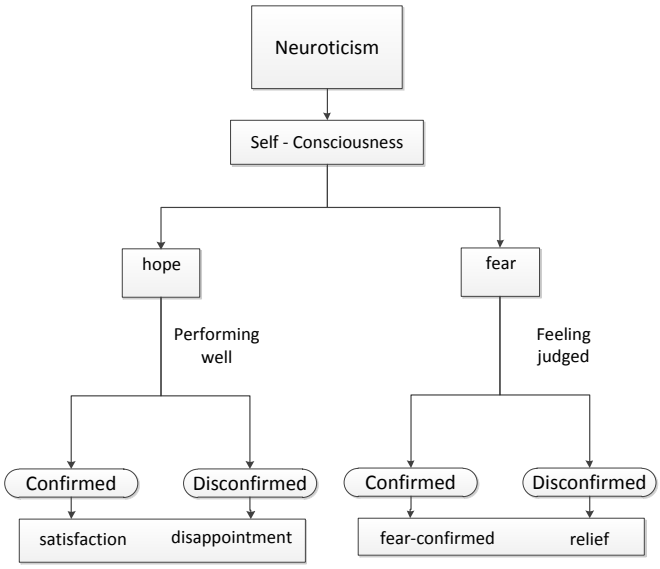

Figure 4.10: Hopes and Fears of a Self-Consciousness Facet of an Neurotic Personality (ORTONY; CLORE; COLLINS 1988)

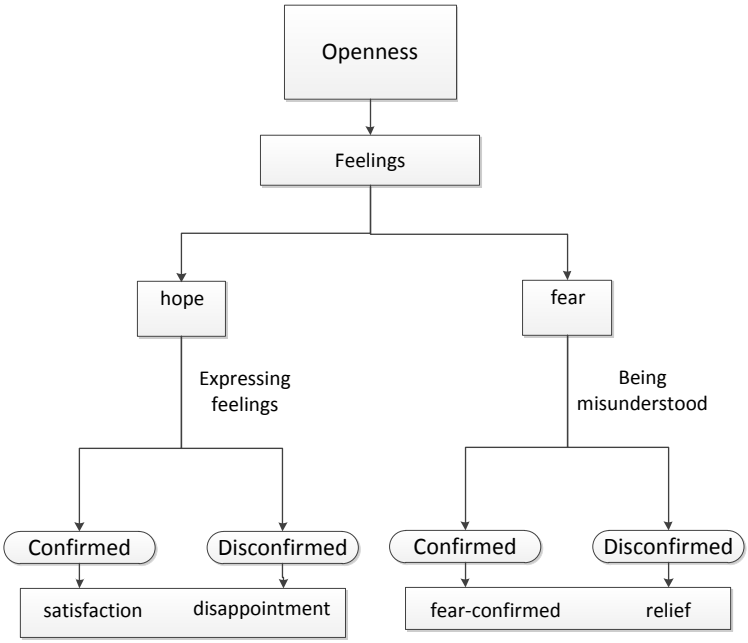

Figure 4.11: Hopes and Fears of a Feeling Facet of an Openness Personality (ORTONY; CLORE; COLLINS 1988)

and creating bonding opportunities).

Figure 4.12 presents our model by showing the relation between the personality facets and the hidden conversation goals of the user in our specific scenario. In the figure,

personality traits and facets are related to specific goals in game and in conversation. In addition, the figure shows the relation between goals in conversation and the choice of speech acts.

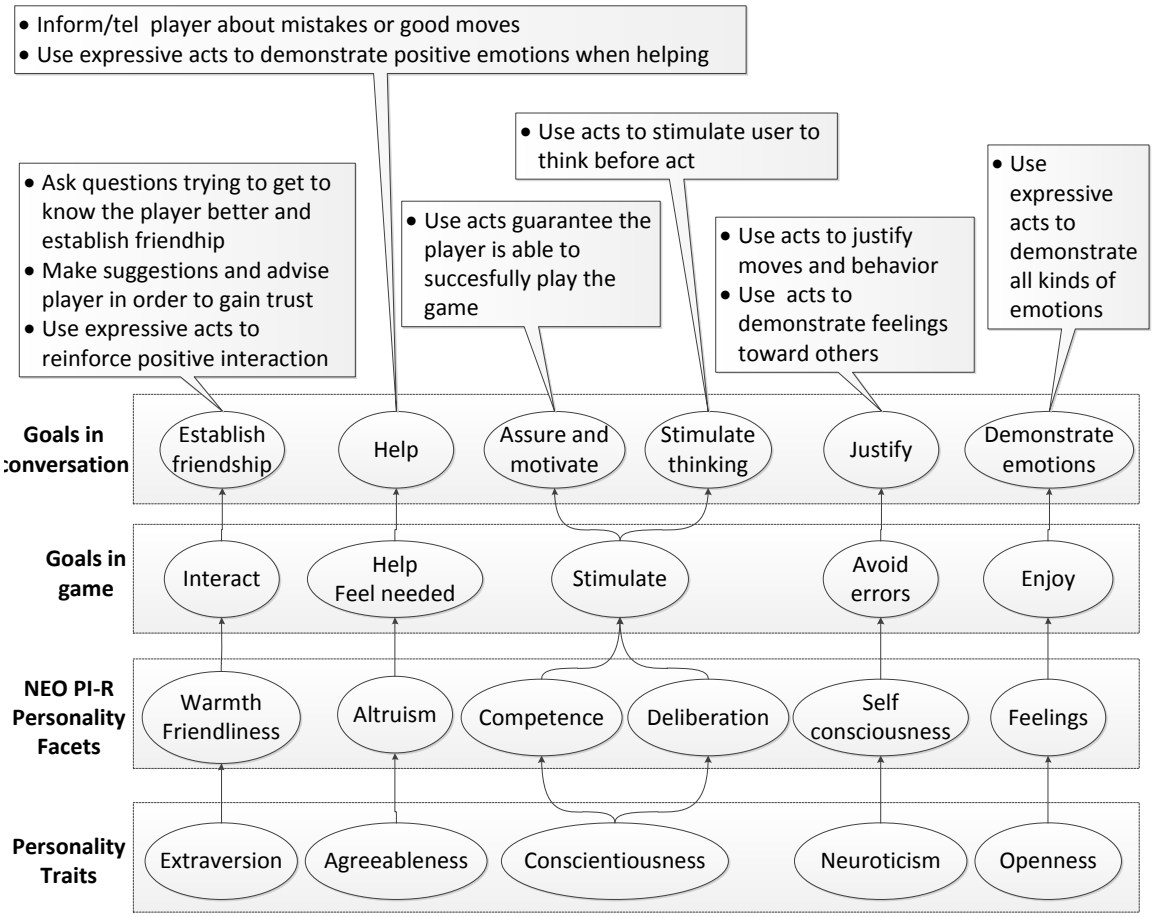

Figure 4.12: Relating goals, speech acts, and behaviors

Table 4.2 summarizes the specific attitudes of our agents for each specific task according to each specific chosen personality facet and specific hidden conversational goals.

4.3 Final Considerations

This chapter presented our approach to enhance affective communication in ECAs. We presented the proposed cognitive model and described how we are using emotion to relate personality, attitudes and verbal behavior.

Next chapter focus on the other categories and subcategories of the taxonomy of relevant design aspects of ECAs (embodiment and implementation). We present how we are applying our mental model in embodied conversational agents. We present the implementation of one personality oriented agent using an expressive communication language and a plan-based BDI approach for modeling and managing dialogue according to our proposed model. This implementation compliments our work by showing how our model can be used to design agents with affective characteristics. Also, the implemented agents will be used later for evaluation purposes (chapter 6).

Table 4.2: Behaviors and Attitudes according to Hidden Conversational Goals (I)

Dimension	Presentation	Observation	Feedback
Extroversion. (Warmth)	Try to establish friendship and gain truth. Ask questions, positive emotions. More gestures, smiles	Be positive when error is made. Comment on moves.	Compliment for finishing the game. Demonstrate interest. Greet goodbye.
Agreeableness. (Altruism)	Explain game with more details. Offer constant help. Positive emotions when helping.	Offer help when error is made. Advise.	Greet goodbye. Demonstrate happiness in being of help.
Conscientiousness. (Competence and Deliberation)	Present the game and advise for precaution while playing. Reinforce the user capacity.	Stimulate user to think before placing a number (error)	Reinforce user is capable of succeeding. Greet goodbye.
Neuroticism (Self -consciousness)	Explain the game with less detail. Complain. Don't look directly.	Become nervous when error is made. Justify wrong moves.	Complain about the game difficulty. Justify if wrong moves were made.
Openness (Feelings)	Demonstrate emotions regarding game and player responses.	Demonstrate all emotions. Right or wrong moves.	Give real feedback (if user made many mistakes or not). Real internal state.

5 APPLYING THE PROPOSED MODEL

The goal of this chapter is to explain how we are applying our proposed model using the expressive conversation language and a BDI approach for dialogue model and management (both presented in chapter 3). We start by discussing our approach for dealing with user input (section 5.1) and present the implementation of one personality oriented agent (section 5.2). We present some transcripts of interactions in order to illustrate our model and implementation (section 5.3). In addition, we explain the toolkit we are using to handle non-verbal communication in our agents (section 5.4).

5.1 Handling User Input

Considering an ideal situation, the user communicates with an ECA just the same way as with a real person. In this ideal case, there is hardly anything to be learnt, as the user has been practicing the type of natural communication in his daily life. If we focus on practice, ECAs are in far from full-fledged humans in their communicational means and some concerns must be taken into consideration (RUTTKAY; PELACHAUD 2004): are users provided with sufficient instructions to understand how to interact with the ECA?

According to (SHNEIDERMAN; PLAISANT 2004) most effective natural language systems require constrained or preprocessed input, or postprocessing of output. Due to this fact, in our scenario, textual user input is restricted. In order to handle input and still be able to perceive some information about user mental states we have adopted some procedures. In a first step, each speech act in the expressive conversational language was mapped to a sentence that assumed the form *"I ask you about the rules of the game"* or *"I am thankful to you for helping me"*. Later we used WordNet[1] and a paper thesaurus (WAITE 2001) to perform a search for all different verbs and expressions related to each conversational act in the language.

We also performed small experiments (figure 5.1) to undestand the way in which people understand written messages. We asked 10 different subjects to perform some tasks orally and also in written form (the tasks were conducted with the presentation of a virtual figure and involved expressing their opinion about the virtual character), for example: "Can you please affirm to me that the hair of this character is brown?", "How would you say that you approve this specific look?". The aim of these experiments were to identify natural language (verbs, expressions, etc) associated with each of the speech acts. After executing this part of the experiment, we exchanged responses between subjects and

[1]WordNet is a large lexical database of English where nouns, verbs, adjectives and adverbs are grouped into sets of cognitive synonyms (synsets), each expressing a distinct concept. Synsets are interlinked by means of conceptual-semantic and lexical relations. The resulting network of meaningfully related words and concepts is free and publicly available for download and for use in the website [2].

asked them to indicate what the sentence written by the other subject expressed (in their point of view). For this part, we changed the original order of sentences, so the subjects would not remember the task before evaluating other responses.

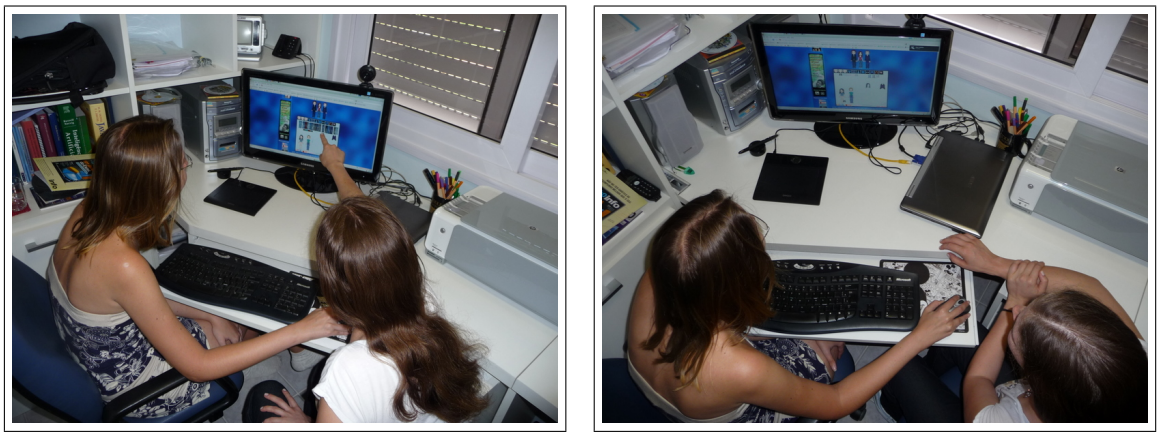

Figure 5.1: User input experiments

After studying and selecting verbs and words, we defined a group of sentences with different possibilities of expressing strength[3] and emotion in written conversation, for example:

I am sorry for you - **(weak strength)**
I am really sorry for you - **(medium strength)**
I am extremely sorry for you - **(strong strength)**

I like it - **(positive emotion toward some object or situation)**
I don't really like it - **(negative emotion toward some object or situation)**

Finally, the sentences were mapped to our specific conversational scenario and tasks. In the end, the user communicates with the agent by choosing a sentence in the conversational area (figure 5.2) and there is no possibility of saying anything different from the possible available choices. The sentences are refreshed at every interaction to reflect the ongoing conversation possibilities.

One example of interaction is shown in figure 5.3. The agent is represented by the robotic figure and, for this particular case, has high score on extraversion - warmth. This is demonstrated in conversation by the choice of the speech act *ask a question* (since the agent tries to establish a friendship and trust before starting to execute the task of presentation. Also, the agent keeps giving positive emotional feedback even knowing the user is not feeling that good. More details on the cognitive model of the agent will be explained later).

One could argue that the experiment chosen for this step of development does not present a great complexity, but it should be noted that our main goal was to understand

[3]This idea of strength can influence the conversation because it can cause impact in the mental state of the agent (or human interacting with the agent)

Figure 5.2: User input possibilities

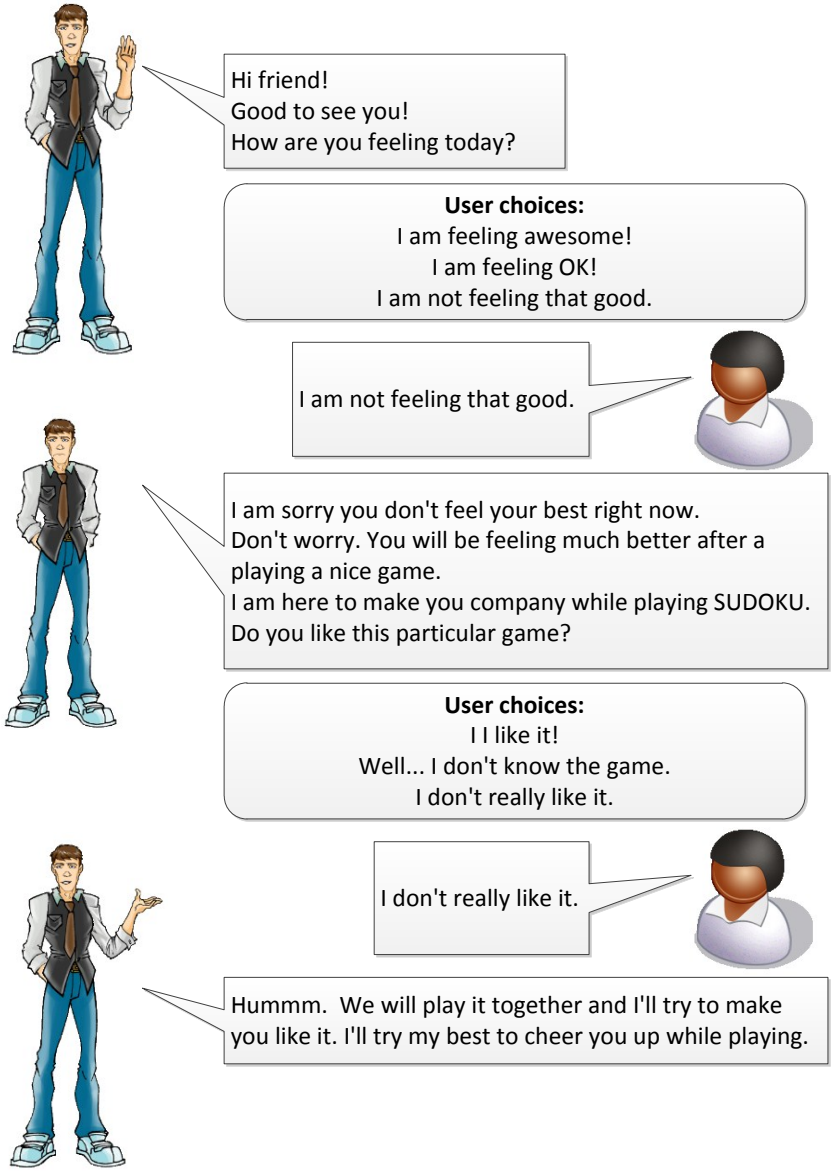

Figure 5.3: Example of an interaction illustrating user input sentence choices

how people express themselves and how they understand the meaning of the sentences they write, not really to present a validation of the language itself. We believe that by performing small experiments where results are easy to visualize, we can reasonably un-

derstand the influence of speech acts in real life scenarios.

5.2 Implementing the Model

The agents developed in this work are BDI agents that incorporates a plan-based dialogue model and plans for coordinating its actions in the environment. The agents were developed using Jason[4]. Jason (Java based AgentSpeak Interpreter Used with Saci For MultiAgent Distribution Over the Net) is a framework that provides a platform for the development of multiagent systems.

The language interpreted by Jason is an extension of the abstract programming language called AgentSpeak(L). AgentSpeak(L) is based on logic programming and the BDI model architecture for agents. The specification language consists of a set of base beliefs (or facts in the logic programming sense) and a set of plans. Plans are context sensitive, event invoked recipes that allow hierarchical decomposition of goals as well as the execution of actions (RAO 1996). The reason for using jason in this work lies on the fact that jason is developed in Java and allows the customization of most aspects of an agent or a multi-agent system. Also, jason is very popular in the research community. Specific literature on Jason ad on how to develop agents using the framework can be found in (BORDINI; HUBNER; WOOLDRIDGE 2007).

In Jason, the beliefs are stored as a collection of literals (belief base) that represent the agent's knowledge about the world. Beliefs are represented as predicates like, for example, *mood(player,negative)* or *easy(game)*. The first means that the agent believes that the mood of he playes is negative while the latter means that the agent believes that the game is easy. In our work, the belief base is composed of beliefs about the personality of the agent (for example: *extroversion(warmth).*). This kind of belief is used to set the personality of the agent and to create plans according to each personality facet. They are set before the execution of the agent (i.e they are already set by the programmer before runtime). During runtime of the agent, other beliefs are added and deleted from the belief base according to the current situation, goals, and plans. One example is the speech acts that are uttered by the player (due to the difficulty of handling user input explained in section 5.1, sentences uttered are mapped directly to beliefs with all the information they carry in the specific scenario). Likewise, emotional information is also stored as beliefs (for example *mood(player,negative)* [5]). These beliefs are particularly relevant for the agent to be able to respond appropriately.

Goals express properties of the states of the world that the agent wishes to achieve. In our agents, goals are used to define the attitudes of the agent in terms of communication (verbal and nonverbal) and also in terms of interferences on the game being played (decide when to interfere). The plans involve how to achieve the goals (i.e. the translation of tasks into real attitudes and verbal communication). Next section will go further in our implementation by showing one illustrative example.

5.2.1 Illustrative Implementation Example: Warm Extroverted Agent

This section presents one example of our work and implementation: the case of a warm extroverted agent. As already mentioned, individuals scoring high on the warmth

[4]http://jason.sourceforge.net/Jason/Jason.html

[5]In this specific case, the agent just asked about user feelings on the particular day he is playing the game and received a negative valenced emotional response. This response is automatically translated to the belief presented

facet (extroversion) demonstrate positive feelings and tend to make friends quickly, forming close and intimate relations. They tend to demonstrate interest in other's life and preferences trying to identify common bonding factors and gain truth. Also, they are described as constantly demonstrating positive feelings toward others to reinforce the positive interaction.

Step 1: initial beliefs and plans

The belief base in our agent is composed initially of the belief about the personality of the agent. In this particular example, the only belief that is present when the agent starts to execute is the belief *extroversion(warmth).* An extrovert agent is proactive (regarding taking initiative in dialogue) and will always initiate the conversation. Figure 5.4 shows a partial initial conversation between the agent and the player. In this particular example, the agent tries to interact with the player during task 1 (presentation) in order to get to know him and establish friendship (asking about likes and dislikes, asking about feelings, and making comments about his own preferences).

Agent first goal is set to *!start*, meaning he will start his first task (presentation). This task involves the presentation of the agent and the game. The influence of personality in this task can vary from the amount of detail given to the amount of interaction with the user. For example: an extroverted agent will explain the game in a simpler way (giving less details) while an agreeable agent with high scores on altruism will explain the game in a more didactic way, offering help when needed.

The *!start* plan is listed in code 5.1. In jason, plans have three distinct parts: the triggering event, the context, and the body. The triggering event and the context form the head of the plan. Plans are written with separators ":" and "<-" as follows:

triggering event : context <- body

Triggering events are used to tell the agent which are the specific events for which the plan is to be used. Events represent changes in beliefs and goals and can be of two types: addition and deletion (belief addition and deletion, achievement goal addition and deletion, test goal addition and deletion). The context is used to check the current situation in order to determine if a particular plan is likely to succeed in handling the event. Finally, the body is a sequence of programming that determines the course of action.

Code 5.1: !start

```
+!start : extroversion(warmth)
        <- .print("(Control Message) Agent is running");
           .print("(Control Message) Personality: extroversion(warmth).");
           .wait(1000);
           .print("(Control Message) Attitude: stand_happy_warmth ");
           stand_happy_warmth;
           .print("(Control Message) Goal: Greet");
           !greet;
           .wait(300).
```

This code shows that an extroverted agent will have the goal of greeting the user before explaining the game (codified by *!greet;*). He will demonstrate an initial happy attitude mainly because establishing a friendship requires interaction and, consequently, having a

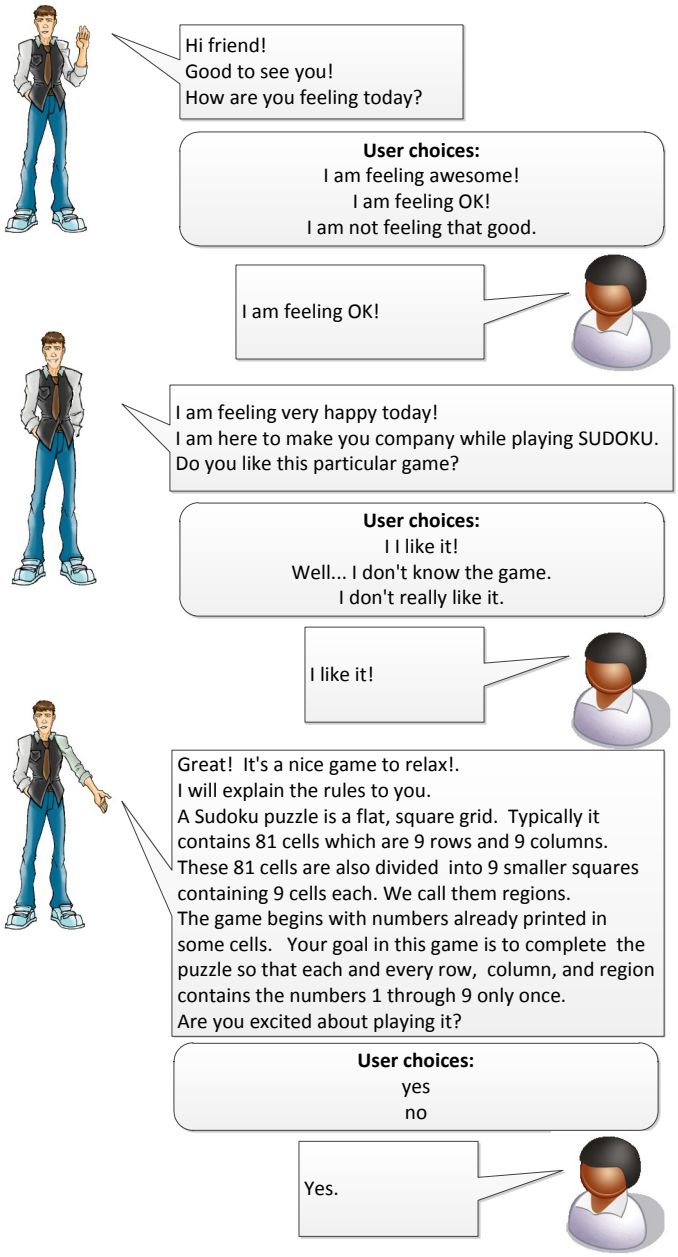

Figure 5.4: Warmth Extroversion Example - Presentation Task (partial)

partner to interact with will make him happy. In our implementation, plans are composed of control messages that will not only log the interaction between both user and player (as for example, the control message *"(Control Message) Agent is running"*), but also trigger the behaviors that are described. Non-verbal behavior of the agent is programmed using DIVA (details in section 5.4). The line with *"stand_happy;"* command represents the programmed chosen non-verbal behavior that must be performed. In this particular case, the agent will have a behavior of standing in a happy way until other behavior is triggered. Standing in a happy way means demonstrating a positive attitude towards the user.

Immediately after, the agent will execute the plan labeled by *!greet;*. This plan is shown in code 5.2. Sentences to be uttered are stored in a database of sentences because

we have decided to adopt a restricted user input where sentences are defined in advance (as discussed in section 5.1). In this example, the line with the command *"greetWarmth;"* indicates that the agent is supposed to utter the specific sentence defined by "greetWarmth" in the database of sentences (in this case: "Hi friend!"). The agent will also express the non-verbal behavior expressed by *"greet_happy;"*.

Code 5.2: !greet

```
+!greet : extroversion(warmth)
    <- greetWarmth;
       .print("(Control Message) Attitude: greet_happy");
       greet_happy;
       .wait(300).
       !affirm(pleased,company);
       .wait(300).
```

Figure 5.5 summarizes this step by showing the log of the intentions and attitudes of the agent.

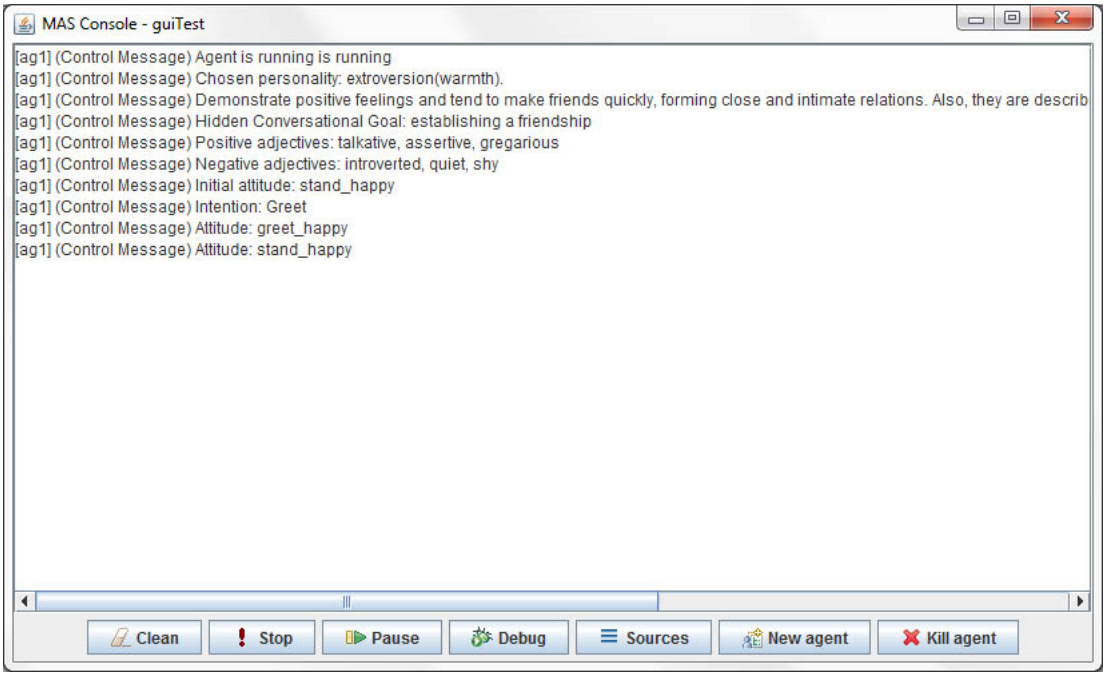

Figure 5.5: First step of execution - log of intentions and attitudes in Jason

Step 2: intentions, plans, and speech acts

If we look to the speech act formalization for greeting we can see that greeting has no specific satisfaction conditions. Therefore, no specific act in response will be expected.

$$
\begin{aligned}
with & \quad (\forall i, j) \\
s & = do(says.to(i, j, \langle greet, p \rangle), s_u, 0, 0) \\
with & \quad (\forall s')(s' \succ s) \\
s_u & = \phi \\
and\ s' & = \phi
\end{aligned}
$$

The performance conditions will be:

$$
\begin{aligned}
success(says.to(i, j, \langle greet, p \rangle), s) & \equiv cond.success(\langle greet, p \rangle)[s] \\
satis_{\phi}(says.to(i, j, \langle greet, p \rangle), s) & \equiv \\
success(says.to(i, j, \langle greet, p \rangle), s) & \supset m(i, p)[do(says.to(i, j, \langle greet \rangle), S_u)]
\end{aligned}
$$

Because no specific act in response is expected, the agent will start trying to bond with the player and will inform the player that his presence makes him pleased (using speech acts to reflect internal emotions). This is expressed by the goal *!inform(pleased,company);* and the sentence *"Good to see you!"*. The formalization of the speech act inform (shown in chapter 3) states that inform is to affirm to someone that a proposition is true presupposing that this person does not know that while having the intention to make this person believe this proposition is, in fact, true.

According to the formalization, the act will achieve success only if: (i) agent i wants to inform p; (ii) p is true in the context; (iii) i presupposes that j ignores p; (iv) i is sincere and really believes p is true. In this particular case, all conditions are successfully achieved because: (i) agent wants to inform the player he is pleased with his company; (ii) this emotion is really present; (iii) the player is unaware of this feeling; and (iv) the agent is sincere. Satisfaction conditions are also present since the agent really is experiencing the feeling and has the intention to make the player believe this feeling is true. We can assume that the player will believe this feeling is true after the utterance since the agent will be demonstrating appropriate matching non-verbal behavior. Again, no specific act in response is required.

After this utterance, the agent will automatically have the goal *!ask(feelings,user);*. This way he will be able to check if the user is prone to interact or not and will learn about user emotional state. This will generate the sentence *"How are you feeling today?"*. Asking has two distinct uses (see formalization below): one is the notion of asking a question and the other is the notion of asking someone to do something. In the sense of "ask a question" it means request that the hearer perform a speech act to the speaker. In other words, the agent will expect the user to tell him about his feelings.

$$
\begin{aligned}
with & \quad (\forall p)(\forall i, j) \\
s & = do(says.to(i, j, \langle ask, p \rangle), s_u, 0, 0) \\
with & \quad (\forall p')(\forall a)\text{where a is a speech act where}(p \Rightarrow a)(\forall s')(s' \succ s)
\end{aligned}
$$

$$
\begin{aligned}
s_u &= bel(i, can(j, a, p')[s] \wedge bel(i, Poss(j, a)) \wedge \\
&\quad wish(i, do(j, a))[s'] \wedge \neg oblig(j, i, a)[s'] \\
and\ s' &= a[s'] \wedge p[s']
\end{aligned}
$$

The performance conditions will be:

$$
\begin{aligned}
success(says.to(i, j, \langle ask, p\rangle), s) &\equiv cond.success(\langle ask, p\rangle)[s] \\
satis_{wl}^{wd}(says.to(i, j, \langle ask, p\rangle), s) &\equiv (\exists s', s'')(s'' \succ s' \succ s) Poss(a, s'), ..., Poss(a, s'') \wedge \\
success(says.to(i, j, \langle ask, p\rangle), s) &\supset p[do(a, do(a, do(a, s''))]
\end{aligned}
$$

The user will have three possibilities of answer: *"I am feeling awesome!"*, *"I am feeling OK!"*, and *"I am not feeling that good."*. Each sentence will be associated with an emotional strength: positive, neutral, or negative. The chosen sentence will generate a belief in the agent belief base. In our example, the generated belief will be *+feelingresponse(neutral)*. The belief will have an associated plan as shown in code 5.3.

Code 5.3: Example of belief when a question is answered

```
+feelingresponse(neutral):   extroversion(warmth)
        <-  -mood(_);
        +mood(user,neutral);
        affirmWarmth_feelingGood;
        .print("(Control Message) - user is neutral -");
        !introduceItself;
        .wait(300).
```

This belief will be later transformed into belief *+mood(user,neutral);*. This way the agent will know how the user is feeling and will be able to adapt conversation to his feelings (an example of a different response selection and the adaptation to user feelings can be seen in figure 5.6).

The agent will go on to the next goal of introducing itself (*!introduceItself;*). If the user fail to answer the question, the success and satisfaction conditions of the act will not be accomplished and the agent will react accordingly. We have defined an amount of time while the agent will expect an answer. When this time passes, a belief will be added to the belief base (as consequence of sensing the environment and getting no response from the user) and the agent will react accordingly (the extrovert agent will utter a sentence and change non-verbal behavior). The rest of the conversation will flow as shown in figure 5.4 until the presentation task is finished. The beliefs, goals, and plans will indicate the attitudes and behaviors of the agent. Also, they will indicate the speech acts that must be uttered.

Step 3: Implementation of other tasks

The other two tasks of the agent are implemented in the same way. In the observation task the agent will be able to sense not only the speech act uttered but also the moves of the

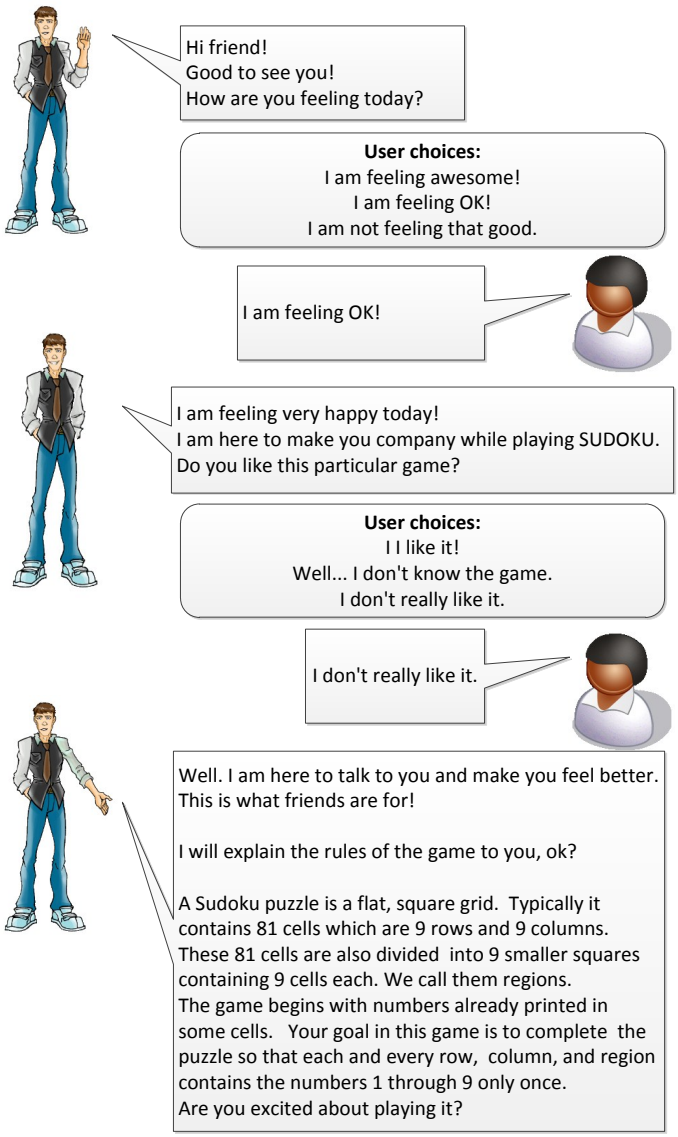

Figure 5.6: Example of a different response selection and the adaptation to user feelings

user in the board. These moves will generates beliefs for right and wrong moves together with information about line and column (one example: *+right(L,C)*). The agent will have plans to react according not only to the conversation (the user can ask for help at any time during the game), but also to react according to an specific move. He will work with beliefs like *line(L,C)*, *column(L,C)*, and *region(L,C)* indicating conflicts of line, column, and region (respectively).

Figure 5.7 shows an example of a wrong move in the game board and the beliefs that are generated by the move. For illustrative purposes, the interface presented in this section is not the same interface presented to users (i.e. the final interface of the system). Instead, we are presenting the version of the interface used to develop the reasoning mechanism of our agent. This interface is used in this section because it provides a log of the details of interactions focusing on implementation issues. In the example of figure 5.7, when

user places the number 7 in line 0 and column 2 (a wrong move since there is another 7 in the same region in line 2, column 1), the log in the interface shows both of the beliefs generated by the system: *wrong(0,2)* and *region(0,2)*.

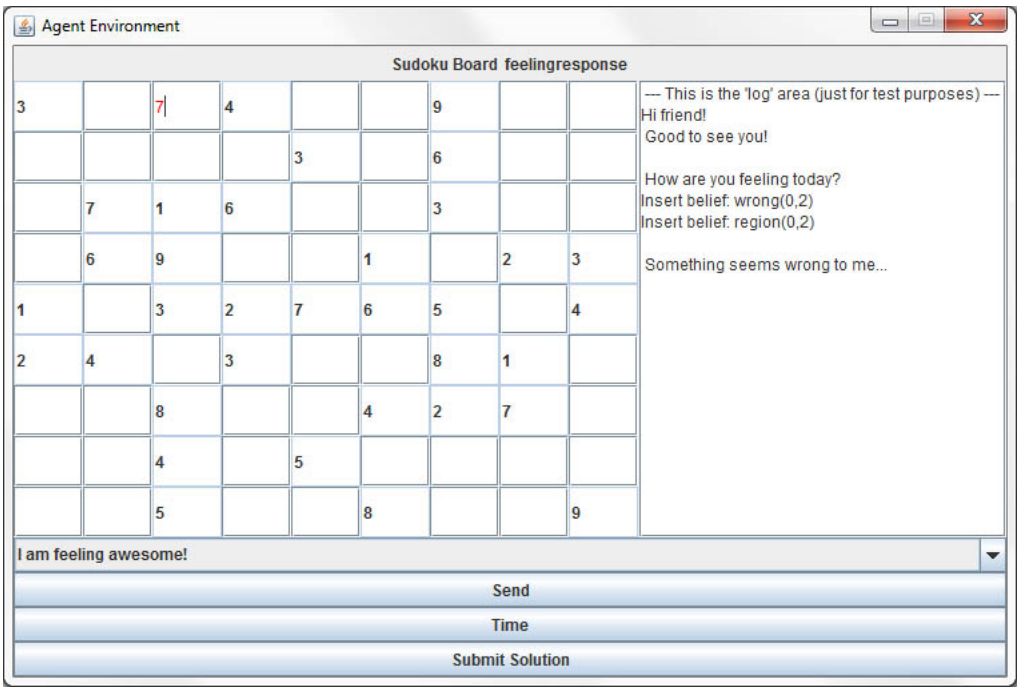

Figure 5.7: Example of beliefs generated by a wrong move of user

Likewise, if the user corrects the number just placed (changing 7 in line 0, column 2 for the number 6), the beliefs of wrong moves will be deleted and a belief indicating a right move will be generated (figure 5.8)

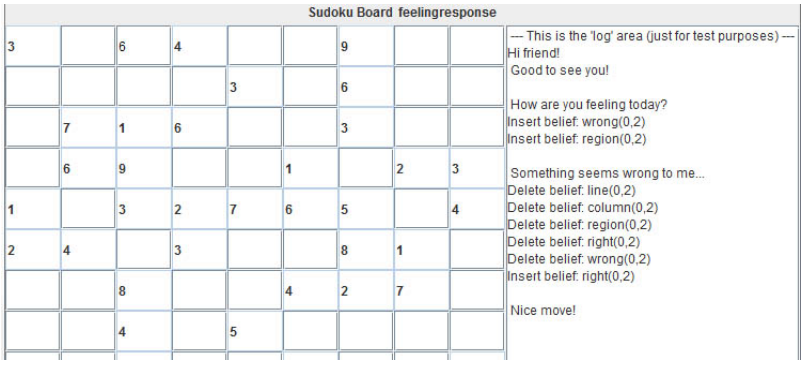

Figure 5.8: Example of beliefs generated by a right move of user

The task of feedback uses the information gathered during the conversation to provide feedback. Figure 5.9 shows an example of conversation of the same extroverted agent. The agent asks the user if he enjoyed his company. If the user answers with a positive response, the agent assumes they are now friends (a belief "*+friend(user)*" is added to the base) and the agent is able to choose speech acts that reflect this feeling (in the example saying *"I am happy being friends with you!"* before saying goodbye.)

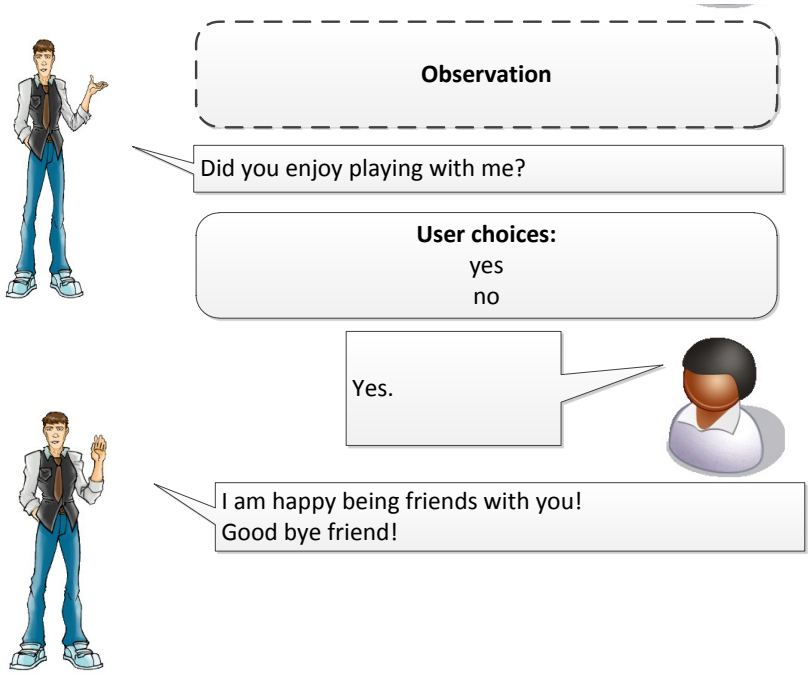

Figure 5.9: Warmth Extroversion Example - Feedback Task

This section provided an example of implementation of one specific personality chosen in this work. The goal is to illustrate how the conversational language was considered in a BDI implementation for the choice of attitudes and speech acts to be uttered by the agent. We explained how to combine the language and proposed model to decide on how to conduct conversation. Other personality facets were implemented the same way, adapting the choice of acts and attitudes according to our model and formalization act characteristics. Next section will briefly show some other examples of different personality facets by transcribing some dialogues.

5.3 Illustrative Dialogue Examples

This section will briefly present some transcriptions of dialogue interactions between user and different personality agents that were implemented. The transcriptions will illustrate how agents were modeled to reflect the behaviors presented in chapter 4.

Since last section provided an illustrative example of implementation of an extroverted agent with high scores on warmth facet, this section will start by presenting two transcriptions of interactions of this specific personality agent. Later, we will also provide some transcriptions of a neurotic self-consciousness agent and an agreeable altruist agent.

- START OF CONVERSATION -
Agent:
(Agent smiles and greets with hand)
Hi friend!
Good to see you!
(Agent stands in a positive mood: smiling)
How are you feeling today?

User:
I am not feeling that good.

Agent:
(Agent makes a sad face for just a moment: expressing sorry)
It's sad you don't feel your best right now.
(agent goes back to the positive attitude and smiles)
I am here to make you company while playing SUDOKU game.
My name is Marco and I will be observing and interacting with you while you play!
Do you like this particular game?

User:
I like it

Agent:
(Agent presents big smile)
Great!
It's a nice game to relax!.
I will explain the rules to you.
(Agent points to the board)
A Sudoku puzzle is a flat, square grid. Typically it contains 81 cells which are 9 rows and 9 columns. These 81 cells are also divided into 9 smaller squares containing 9 cells each. We call them regions. The game begins with numbers already printed in some cells.
Your goal in this game is to complete the puzzle so that each and every row, column, and region contains the numbers 1 through 9 only once.
(Agent presents big smile)
Are you excited about playing it?

User:
No

Agent:
(Agent express a sad face for just a moment)
Hummm.
(Agent returns to happy attitude)
You will enjoy playing with me. I am sure. We can keep talking while playing.
Well... before playing i will present the interface to you, ok?
(Agent points to the right place in the interface where answer selection is)
As you probably guessed by now, here is where you can select what you want to say to me
(Agent points to the right place in the interface where the log of conversation is shown)
Our conversation will be shown here
(Agent points to the board)
You can see the SUDOKU board here. This is where you will place the numbers.
(Agent points to buttons)
Clicking check will make me help you while clicking clear will clear the whole board game
(Agent smiles)
Go on... it's time to play!

User:
(User places a right move on line 0, column 2)

- Insert belief: right(0,2) -

Agent:
(gesture of victory)
Nice move!

User:
(User places a wrong move on line 1, column 3)
- Insert belief: wrong(1,3) -
- Insert belief: line(1,3) -
- Insert belief: column(1,3) -
- Insert belief: region(1,3) -

User:
(User places a right move on line 0, column 1)
- Insert belief: right(0,1) -

Agent:
(gesture of victory)
Nice move!

- The game goes on until the user finishes it -

Agent:
(Agent shows very happy expression and congratulation expression)
Congratulations for finishing the game!
Did you enjoy playing with me?

User:
Yes

Agent:
You played very well. I am happy being friends with you!
(Agent smiles and greets with hand)
Good bye friend!
- END OF CONVERSATION -

Another conversation with the same personality agent is transcribed below:

- START OF CONVERSATION -
Agent:
(Agent smiles and greets with hand)
Hi friend!
Good to see you!
(Agent stands in a positive mood: smiling)
How are you feeling today?

User:
I am feeling awesome!

Agent:
(Agent makes a very happy face)
I am feeling very happy today!
(Agent smiles gently)
I am here to make you company while playing SUDOKU game.
My name is Marco and I will be observing and interacting with you while you play!
Do you like this particular game?

User:
I like it

Agent:
(Agent makes a very happy face)
Great! It's a nice game to relax!.
(Agent smiles gently)
I will explain the rules to you.

- Agent explains the game -
- Agent reacts to user moves until the user finishes the game -

Agent:
(Agent shows very happy expression and congratulation expression)
Congratulations for finishing the game!
Did you enjoy playing with me?

User:
No

Agent:
(Agent express a sad face for just a moment)
I am sorry to hear that
Ok. Good bye!
(Agent smiles gently)
I would love to see you back soon!
- END OF CONVERSATION -

Table 5.1 shows the expected behavior of such agent according to our model. The example shows that the agent keeps asking questions in order to create some kind of bond with the user (i.e. ask the user about his feelings, likings, emotions...). Also, the agent keeps a positive attitude during the dialogue: he compliments the good moves of the user and demonstrates interest in him. The first transcription is presented below:

Table 5.1: Behaviors and Attitudes - Warmth Extroverted Agent

Dimension	Presentation	Observation	Feedback
Extroversion. (Warmth)	Try to establish friendship and gain truth. Ask questions, positive emotions. More gestures, smiles	Be positive when error is made. Comment on moves.	Compliment for finishing the game. Demonstrate interest. Greet goodbye.

Since the warm extroverted agent tries to establish a friendship with the user by asking questions about user feelings and likings, he is programmed to react to the answers (emotions of the user). In the first example, when the user tells the agent he is not feeling that well (*I am not feeling that good.*), the agent reacts by expressing he is sorry for the user (*It's sad you don't feel your best right now.*). In the second example, the agent reacts to the positive emotions of the user (*I am feeling awesome!*) by expressing he is also feeling happy (*I am feeling very happy today!*). The personality of the agent is also expressed in the end of the game. The agent compliments the user for finishing the game and asks if the user enjoyed his company. In the first example, the user answers he enjoyed the company of the agent and, therefore, the agent starts to react in a more intimate way with the user. In the second example, on the other hand, the user says he did not enjoyed the company of the agent and, consequently, the agent maintains a positive attitude telling he expects to meet the user again soon.

Table 5.2 summarizes the attitudes and behaviors of a neurotic self-consciousness agent. According to our model, this agent hopes to perform well and fears to be judged (although the hope of performing well is not directly related to our specific scenario, we have created our model considering hopes and fears in a generic way) and will act according to the hidden conversational goal of justify wrong behaviors of users.

Table 5.2: Behaviors and Attitudes - Neurotic Self-Consciousness Agent

Dimension	Presentation	Observation	Feedback
Neuroticism (Self -consciousness)	Explain the game with less detail. Complain. Don't look directly.	Become nervous when error is made. Justify wrong moves.	Complain about the game difficulty. Justify if wrong moves were made.

Both transcriptions presented below shows that the agent has a behavior of avoiding being judged. Also, the negative feelings usually associated with this agent are also present. One example of this behavior happens when the agent says *If someone is coming, you can always click clear and no one will notice the wrong moves.* and *You should pretend you have just started playing and you will not look like a loser.*.

- START OF CONVERSATION -
Agent:
(Agent looks down)
Hi.
I am here to make you company while playing SUDOKU game.
(Agent stands in a normal way)
My name is Marco and I will be observing and interacting with you while you play!
You know... this is a hard game.
(Agent looks both sides very quickly)
I don't play it very frequently.
(Agent stands with sad eyes and normal mouth)
I will start by explaining the game so you won't make mistakes while playing...
A Sudoku puzzle is a flat, square grid. Typically it contains 81 cells which are 9 rows and 9 columns. These 81 cells are also divided into 9 smaller squares containing 9 cells each. We call them regions. The game begins with numbers already printed in some cells.
Your goal in this game is to complete the puzzle so that each and every row, column, and region contains the numbers 1 through 9 only once.
(Agent looks both sides very quickly)

Are you afraid?

User:
No

Agent:
(Agent makes a surprise face for just a moment)
Don't tell me I didn't warn you about the game difficulty, ok?
(Agent stands with sad eyes and normal mouth)
Some information on the interface for you...
(Agent turns face to the place in the interface where the box with answers is located) As you probably guessed by now, here is where you can select what you want to say to me
(Agent turns face to the place in the interface where the conversation log box is located) Our conversation will be shown in the box there
(Agent turns face to the place in the interface where the board is located) You can see the SUDOKU board here this is where you will place the numbers
(Agent stands with sad eyes and normal mouth)
Clicking check will make me help you while clicking clear will clear the whole board game
(Agent looks both sides very quickly)
Go on... it's time to play!

User:
(User places a series of wrong numbers)
-Insert belief: wrong(3,3)
-Insert belief: line(3,3)
-Insert belief: wrong(3,4)
-Insert belief: line(3,4)
-Insert belief: region(3,4)
-Insert belief: wrong(3,6)
-Insert belief: line(3,6)
-Insert belief: column(3,6)
-Insert belief: wrong(3,0)
...
- After 4 wrong numbers -

Agent:
(Agent looks directly to the user)
There are plenty of conflicts in the board.
I told you this game is hard.

User:
(User places more wrong numbers)
...
- After 10 wrong numbers -
(Agent looks both sides very quickly)
If someone is coming, you can always click clear and no one will notice the wrong moves.
You should pretend you have just started playing and you will not look like a loser.

- The game goes on until the user finishes it -

Agent:

(Agent looks directly to the user)
You finally did it.
This game is just too much of a challenge.
(Agent looks both sides very quickly)

User:
I disagree. The game is OK.

Agent:
(Agent looks down)
Ok. Good bye!
- END OF CONVERSATION -

Another conversation with the same personality agent is transcribed below. This example shows that when the users agree with the neurotic personality of the agent, he tends to react in a less agressive way by saying *I understand.* or *I told you so.*.

- START OF CONVERSATION -
Agent:
(Agent looks down)
Hi.
I am here to make you company while playing SUDOKU game.
(Agent stands in a normal way)
My name is Marco and I will be observing and interacting with you while you play!
You know... this is a hard game.
(Agent looks both sides very quickly)
I don't play it very frequently.
(Agent stands with sad eyes and normal mouth)
I will start by explaining the game so you won't make mistakes while playing...
A Sudoku puzzle is a flat, square grid. Typically it contains 81 cells which are 9 rows and 9 columns. These 81 cells are also divided into 9 smaller squares containing 9 cells each. We call them regions. The game begins with numbers already printed in some cells.
Your goal in this game is to complete the puzzle so that each and every row, column, and region contains the numbers 1 through 9 only once.
(Agent looks both sides very quickly)
Are you afraid?

User:
Yes

Agent:
(Agent looks directly to user)
I understand.
(Agent stands with sad eyes and normal mouth)
People tend to find this game easy. It's not.
Some information on the interface for you...
(Agent turns face to the place in the interface where the box with answers is located) As you probably guessed by now, here is where you can select what you want to say to me
(Agent turns face to the place in the interface where the conversation log box is located) Our conversation will be shown in the box there
(Agent turns face to the place in the interface where the board is located) You can see the

SUDOKU board here this is where you will place the numbers
(Agent stands with sad eyes and normal mouth)
Clicking check will make me help you while clicking clear will clear the whole board game
(Agent looks both sides very quickly)
Go on... it's time to play!

User:
(User do not click anywhere on the interface for 5 minutes)

Agent:
(Agent looks both sides very quickly)
Humm
Do you want people to know you can't play this game?

- The game goes on until the user finishes it -

Agent:
(Agent looks directly to the user)
You finally did it.
This game is just too much of a challenge.

User:
I agree with you

Agent:
I told you so.
(Agent express an angry emotion)
Don't blame me for your mistakes!
Ok. Good bye!
- END OF CONVERSATION -

The last example is of an agreeable altruist agent. Table 5.3 shows the modeled behaviors and attitudes according to our proposed model of hidden conversational goals. This agent has the HCG of helping and, different from the extroverted agent, he will ask if the user wants help or will offer advice to the user (even without being asked to do so). He will demonstrate to be happy for helping and will give more detailed explanations about the game.

Table 5.3: Behaviors and Attitudes - Agreeable Altruist Agent

Dimension	Presentation	Observation	Feedback
Agreeableness. (Altruism)	Explain game with more details. Offer constant help. Positive emotions when helping.	Offer help when error is made. Advise.	Greet goodbye. Demonstrate happiness in being of help.

- START OF CONVERSATION -
Agent:
(Agent greets with a normal face)
Hello.

I am here to make you company while playing SUDOKU game.
My name is Marco and I will be observing and interacting with you while you play!
Have you ever played this game before?

User:
No. I never did.

Agent:
(Agent smiles) You will probably need some help then.
Great!

Agent:
(Agent start explanation and keeps smiling while explaining)
I will explain the rules to you.
A Sudoku puzzle is a flat, square grid. Typically it contains 81 cells which are 9 rows and 9 columns. These 81 cells are also divided into 9 smaller squares containing 9 cells each. We call them regions.
The game begins with numbers already printed in some cells.
Your goal in this game is to complete the puzzle so that each and every row, column, and region contains the numbers 1 through 9 only once.

Agent:
There are 9 rows in a traditional Sudoku puzzle.
Every row must contain the numbers 1, 2, 3, 4, 5, 6, 7, 8, and 9. There may not be any duplicate numbers in any row.

Agent:
There are 9 columns in a traditional Sudoku puzzle.
Like the Sudoku rule for rows, every column must also contain the numbers 1, 2, 3, 4, 5, 6, 7, 8, and 9.
Again, there may not be any duplicate numbers in any column. Each column will be unique as a result.

Agent:
There are 9 regions in a traditional Sudoku puzzle.
A region is a 3x3 box. Like the Sudoku requirements for rows and columns, every region must also contain the numbers 1, 2, 3, 4, 5, 6, 7, 8, and 9.
Duplicate numbers are not permitted in any region. Each region will differ from the other regions.

Agent:
You must keep scanning the puzzle looking for hints on where to place a particular number.

Agent:
(Agent presents big smile) I am happy to help you understand the game.
You should also know that...
You can try some strategy to solve it. For example: look for regions with most givens, look for a particular number and check where it can go or not inside a region...
It doesn't matter where you start placing numbers. I suggest looking for the number that has several 'givens'. The more givens of a particular number often means that it will be easier to solve.

User:

(User places wrong numbers)
-Insert belief: wrong(3,3)
-Insert belief: line(3,3)
-Insert belief: wrong(1,1)
-Insert belief: column(1,1)
-Insert belief: region(1,1)
-Insert belief: wrong(3,6)
-Insert belief: line(4,1)
-Insert belief: column(4,1)
...
- After some wrong numbers -

Agent:
(Agent makes a stop gesture) Humm. You have some conflicts of line, column or region.
I will be here for you just in case you need any help, ok?
Would you like me to help you with your game so far?

User:
I don't need help.

Agent:
(Agent makes a sad face) It seems complicated, but it gets easier with practice!

- The game goes on until the user finishes it -
- Agent keeps offering help or giving hints until the user is done -

Agent:
It's done. You did well!

- The user has the option to thank the agent for help at this moment -
- The agent waits 35 seconds for user to say something -
- In this example, the user does not thank the agent -

Agent:
(Agent express a sad emotion)
I hope I can help you next time
Good bye!
- END OF CONVERSATION -

The transcripts presented in this section helps to understand our model and its application in real agents using the expressive conversation language and a BDI approach to model dialogue. Next section will explain how we are dealing with non-verbal communication of agent.

5.4 Dealing with Look and Non-verbal Communication

Since non-verbal attitudes are not the focus of this work, non-verbal behavior implementation in our agents followed current studies about facial expressions and gestures (non-verbal modalities we are considering). Facial expressions improve communication, help disambiguate utterances and accompany speech in order to help during conversation timing and goals. Specific work considering different aspects of facial displays can be found in recent literature. In chapter 1 of the

book *Embodied Conversational Agents* (CASSELL et al. 2000) four categories of facial display are presented according to their role in conversation:

- Planning ⇀ Used when speakers organize their thoughts. As an example, they tend to look away in order to prevent an overload of information.
- Comment ⇀ Used when the speaker wants to emphasize some linguistic items
- Control ⇀ Used to regulate turns in conversations and to regulate the use of communication channel
- Feedback ⇀ Used to provide and elicit feedback

Lance and Marsella (2008) focus on gaze behavior that can be expressed not only in terms of where the gaze is directed but also in how the gaze is performed (physical manner). In their work, they try to find a model that maps between emotion and physical manner of gaze in order to increase the believability of virtual embodied agents. Another recent work that can fit in this specific aspect is the work of Cafaro et. al. (2009) where they aim to produce naturally looking gaze behavior for animated agents and avatars that are simply idling. In order to achieve their goals, they study people standing and waiting, as well as people walking down a shopping street.

Gestures and body movements are very important in face-to-face conversation because they accompany speech in most communicative situations and in most cultures. People use gestures and body movements to describe a scene or talk about objects and actions in space. Moreover, people use a very wide variety of gestures ranging from simple actions of using the hand to point at objects, to the more complex actions that express feelings and allow communication with others (JAIMES; SEBE 2007). These gestures complement and supplement the information conveyed in language, but their meaning depends on the linguistic context in which they are produced A taxonomy of gestures that are commonly used by humans and can serve as key roles for the construction of ECAs is also presented in the book *Embodied Conversational Agents* (CASSELL et al. 2000):

- Emblems or emblematic gestures ⇀ These gestures are culturally specified and may represent different meanings in different cultures.
- Propositional gestures ⇀ These gestures are used in conversations where the physical world in which the conversation is taking place is also the topic of conversation. For example: the use of the hands to measure the size of a symbolic space while saying it was this big.
- Spontaneous gestures ⇀ These gestures are unconscious and unwitting. They can be divided in four types: iconic (may specify the viewpoint from which an action is narrated. Also, they may represent some feature of one action or event being described. They bear a resemblance to what is represented by the gesture), metaphoric (represent common metaphors. For example, people can use a rolling gesture to indicate ongoing process or time), deictic (represent entities that have a physical existence. They populate the space in between the speaker and listener with the discourse entities as they are introduced and continue to be referred to) and beat gestures (small movements that do not change in form with the content of the speech. Also, they can serve to check on the attention of the listener as well as to ensure that the listener is following).

Specific studies on how to relate personality, emotions, and behavior were also considered. We adapted literature about personality traits and non-verbal behaviors according to our specific needs. One example is the work of (BALL; BREESE 2000) where the authors say that dominant personality traits are strongly communicated by postures and gestures that demonstrate a readiness for aggressive action. Body positioning that emphasizes personal size, a strong upright posture, hands placed on the hips, and directly facing the listener all convey dominance. Bending back and

tilting the head back suggests arrogance and disdain. A relaxed, asymmetrical positioning of the body conveys fearlessness, which also suggests dominance. Gestures like reaching forward with palms down, slapping a surface or focusing a direct unwavering gaze at another, also communicate a dominant personality type.

By contrast, submissive personalities tend to adopt postures that minimize size and position their bodies at an angle. Submissive gestures include bowing (showing harmlessness), gazing down, tilting the head to the side, reaching out with palms up, and shrugging the shoulders. A friendly personality (as well as positive emotional valence) is communicated by postures and gestures that increase accessibility to a conversational partner. These include leaning forward, directly orienting the body, placing arms in an open position, and a direct gaze (when coupled with a forward lean and smile). In addition, submissive displays, such as shoulder shrugs and tilted head, indicate harmlessness and signal friendly intent (BALL; BREESE 2000).

In this work, physical appearance of the agent is based on DIVA (DOM Integrated Virtual Agents) toolkit [6]. This choice can be justified by the fact that DIVA toolkit is relatively easy to use and adapt and the complexity of this adaptation is not as high as the complexity of creating a new one from scratch. According to the creators, the main objective of DIVA is to offer an easy and comprehensive way for developing and deploying conversational virtual agents that are completely integrated with the DOM structure of the web pages. DIVA toolkit offers a variety of cartoon-like and realistic characters. Figure 5.10 shows some examples of available toolkit characters.

Figure 5.10: Example of DIVA toolkit characters

DIVA toolkit offers a variety of possibilities regarding nonverbal communication ranging from facial expressions to body movements (figure 5.11). The toolkit offers different eye and mouth expression possibilities that are labeled according to emotions that can be conveyed (happy, sad, angry, ...). Also, a set of gaze possibilities are available (up, down, front, left, right, ...). Since they are independent, several facial expressions can be created by combining eye, mouth and gaze possibilities. Moreover, the toolkit offers a variety of arm positions (figure 5.12 shows some of the left arm position possibilities), head and body positions, and hand gestures that can also be combined in several ways.

5.4.0.1 Coding nonverbal communication in DIVA

DIVA characters are designed with separated parts: body, left arm, right arm, head, eye, mouth, and gaze. Combined, these parts form a figure representing the virtual agent appearance. Code 5.4 shows a codification of one position where the body parameter is called front (as if looking to

[6] http://www.limsi.fr/ jps/online/diva/divahome/

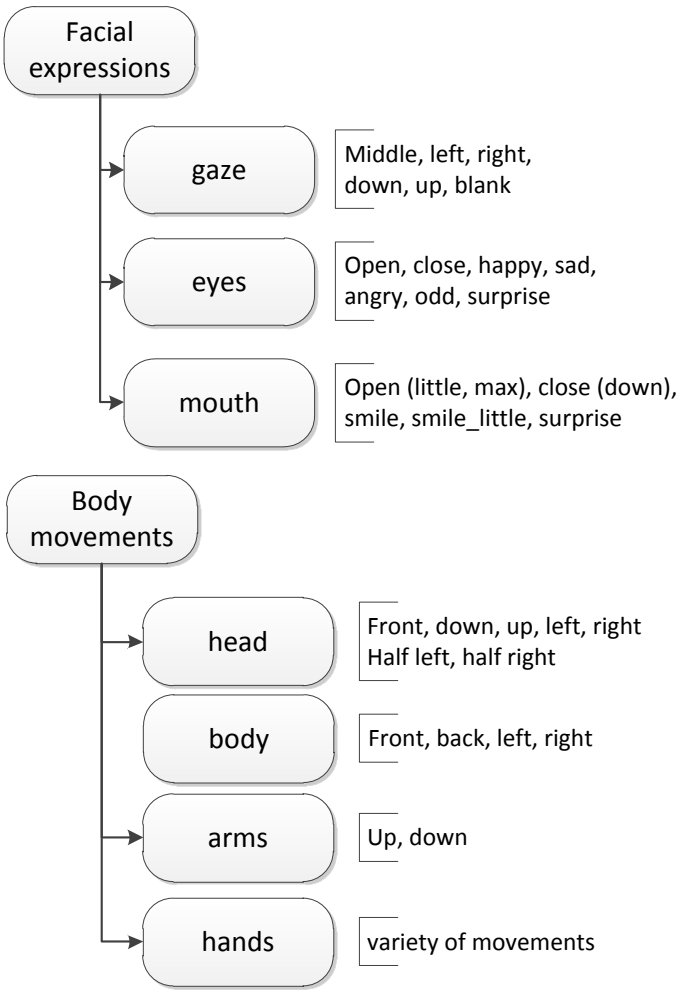

Figure 5.11: Agent communication possibilities

the user), the right arm is pointing down, the left arm is behind agent back, and the head is down (see figure 5.13). In the rest of this document we will refer to an agent position as a position set.

Code 5.4: point down

```
POINT_DOWN = [

    [10, ["body/front", "rightarm/show_down", "leftarm/drop",
          "toparms/null", "head/down", "mouth/null",
          "eyes/null", "gaze/null"]
    ]

];
```

The parameters mouth, eyes, and gaze are set to null since some head possibilities have fixed characteristics. The parameter *toparms* is also set to null since it is not being used. This parameter is used when specific behaviors are needed (normally using both arms to convey some specific emotion/attitude). Animation of characters can be done by combining several positions. One example is shown in code 5.5 that illustrates the sequence of figure 5.12. The number before a

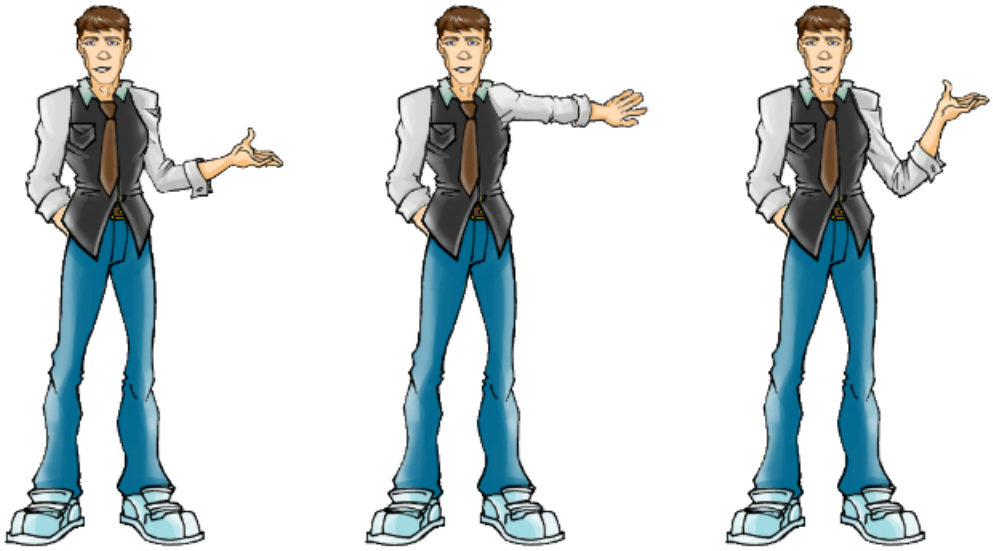

Figure 5.12: Example of left arm movement possibilities

Figure 5.13: Marco showing something down

position set means the amount of time that this specific position will appear in screen before the next one starts to be shown.

Code 5.5: left arm example

```
LEFT_ARM_EXAMPLE = [
    [10, ["body/front", "rightarm/drop", "leftarm/hand_middle_left",
```

```
        "toparms/null", "head/front", "mouth/open_smile_little",
        "eyes/open_happy", "gaze/middle"]
    ],

    [10, ["body/front", "rightarm/drop", "leftarm/hand_middle_left_2",
        "toparms/null", "head/front", "mouth/open_smile_little",
        "eyes/open_happy", "gaze/middle"]
    ],

    [10, ["body/front", "rightarm/drop", "leftarm/hand_up_left",
        "toparms/null", "head/front", "mouth/open_smile_little",
        "eyes/open_happy", "gaze/middle"]
    ],

];
```

Although the position set offers no specific parameter for hand gestures, they can still be performed. Code 5.4, for example, has the parameter *rightarm* set to *show_down*. In this case, *show_down* is a gesture that involves not only an arm movement, but also a finger movement. Specific gestures are codified together with specific body parts in the toolkit.

5.5 Final Considerations

The purpose of this chapter was to present how to apply our proposed model in an ECA. We presented the toolkit used for dealing with embodiment issues (appearance, motion possibilities, facial display, use of hand and body, etc) of the agent. We explained how to implement non-verbal communication and demonstrated the possibilities of non-verbal behavior we have available. More important, we finished presenting our innovative approach to model verbal communication in ECAs trying to increase their believability and to enhance human-agent affective communication. We explained the implementation combining our model with BDI approach for dialogue modeling (and management) and expressive conversational language. Next chapter will discuss evaluation strategies and conclusions together with the limitations we have faced in our evaluation experiments.

6 PROTOTYPE VALIDATION

Evaluation research can be defined as a collection of information about how a specific software application works for a specific group of users in a specific predefined context (CHRISTOPH 2004). The primary goal of this chapter is to present the strategies adopted to evaluate our work. We will present literature regarding evaluation strategies for ECAs (sections 6.1 and 6.2) and will discuss specific strategies according to the research areas of this work (section 6.3). We will describe evaluation settings, procedures, and results (sections 6.4 and 6.5).

6.1 Overview

Evaluation is an essential task to the real successful applications of ECAs. Evaluation can be used to define if the ECA has added effect in dimensions other than the attraction of novelty (RUTTKAY; PELACHAUD 2004). According to Ruutkay, Dormann and Noot (2004), the target of evaluation can be seen as one of the following:

- Find out the effect of single or multiple basic design parameters of the ECA on the perception and performance of the user (evaluation on the ECA itself). Specific goals inside this category include:
  - Test if a specific ECA fulfills some expectations;
  - Find out how to set certain parameters of the ECA to achieve some desired characteristics.
- Find out about the merit of using ECAs for a given application (ECA as a user interface evaluation). Specific goals inside this category include:
  - Test if a specific ECA has added value;
  - Investigate what ECA is the best for a given application.

Next session will discuss specific metrics and strategies commonly used to evaluate ECAs.

6.2 Metrics and Strategies for Evaluating ECAs

Among the strategies that can be used to evaluate ECAs, the most commonly used are: survey, experiment, and case study (CHRISTOPH 2004).

- Survey → A survey can be used to collect information from participants in order to obtain a general view of the population involved in the evaluation process. In a survey, the number of participants is large. Common survey techniques include: distributed questionnaires and interviews.

- Experiment → An experiment is used to identify causal relationships. In an experiment, the conditions must be controlled. One example is the generally used experiment of setting two versions of the same application: one with the ECA and the other without to study if the ECA changes the attitude of the user.

- Case Study → A case study is used to collect information in depth about some specific phenomenon. Common case study techniques include: observation and interviews.

Several techniques for data collection can be adopted (ISBISTER; DOYLE 2004; RUTTKAY; DORMANN; NOOT 2004; CHRISTOPH 2004) according to each specific category:

- Interview → Concerns opinions and attitudes of people. During an interview, participants should be able to express their opinions freely. Due to this fact, the interviewer should not be related to the agent or application development team. Provides mainly qualitative data. Although frequently used to evaluate ECAs, interview technique may bias the subjects answers (RUTTKAY; DORMANN; NOOT 2004).

- Observation → Observation can be used both in early and final stages of development. In early stages, observation can help designers to generate the requirements for the agent (observing how a teacher explains some topic in order to adapt to an ECA) while in the final stages observation can help verifying the behavior of the user while interacting with the ECA. Observation enables access to more private events (corporal reactions while interacting with the ECA, for example).

- Questionnaires → Also related to opinions and attitudes of people. Quations can be of two types: open and closed ones. Open questions enables participants to write answers in their own words. The advantage (comparing to the interview) is that the participants will not have the presence of a mediator and this fact can lead to more sincere opinions. Closed questions reduce the time for interpretation and can have different formats: semantic differential questions (opposite adjectives to be chosen by the participant relating to some specific quality or characteristic) and rating scales (list of alternatives that range from two extremes - example: "agree" and "disagree").

- Usage Data (Log Files) → Provides quantitative characteristics of interaction of the user, based on log files, for example. The system can have some sort of data capturing module logging some aspects of user (or system) behavior.

- Heuristic Evaluations → Concerned with testing some accepted heuristics like: learnability, efficiency, memorability, errors, among others that can be found in literature.

- Biological and/or Biomedical Data → use of biological or biomedical measures like heart rate or skin conductivity. The purpose is to get a set of data not based on self-report techniques that are prone to subjectivity.

It is important to mention that many problems can arise while evaluating ECAs. As mentioned in chapter 3, human communication is very complex and we have no commonly accepted definitions of some natural language terms commonly used while evaluating these systems like **trust** and **like**, for example. Next section will discuss the evaluation strategies adopted in this work.

6.3 Evaluation strategies for this work: purposes and hypotheses

Table 6.1 summarizes some evaluation strategies for major categories of ECA research considering the taxonomy presented in chapter 1 (2004). For validation purposes we focus on the

believability aspect since we are interested in increasing believability of ECAs. Considering believability, tests include objective and subjective characteristics that involve evaluating some aspects of the agent (appearance, voice, reactions) and evaluating reactions to behaviors, attribution of goals and emotions.

Table 6.1: Evaluation strategies for major categories of ECA research (ISBISTER; DOYLE 2004)

Category	Subjective	Objective
Believability	Does the user find the agent's appearance, voice, and reactions believable? Does an expert?	Does the user react physiologically and behaviorally as if dealing with an equivalent "real" person? Does the user engage in ways that demonstrate s/he treats the agent's behavior as believable (reactions to behaviors, attribution of goals and emotions).
Sociability	Qualitative measures from user of agent's friendliness, helpfulness, social qualities, communication abilities. User's evaluation of overall experience: speed, ease, satisfaction.	Measures of elicited social responses to the agent. Behavioral changes predicted by social tactics used (more influence of agent on user's answers, more reciprocal aid of agent).
Application Domains	Measures of user satisfaction with task and interaction	Behavioral outcomes (performance on tasks, memory)
Agency and Computational Issues	Elegance of system, parsimony.	Successful operation of the agent in 'real world' domains according to criteria of speed, efficiency, optimality, reliability, error handling, among others.

In order to find out if the developed agent is believable, a case study was performed to verify if users are able to recognize personality aspects of the agent and if they could recognize hidden communicative goals in conversation. Data collection used questionnaires and log files to measure user satisfaction. Questionnaires were used instead of interviews because they didn't require the presence of a mediator and allowed participants to express more sincere opinions. Considering the work of Ruutkay, Dormann and Noot (2004), we are interested in finding out the effect of our design approach on the perception of the users. One could argue that testing if an agent increases believability in conversation should include a controlled experiment as presented in section 6.2. In our case, we are first interested in testing if our approach makes the agent believable by itself before comparing with different approaches. As explained in previous chapters, our model of dialogue combined an expressive conversational language and personality facets. Due to this fact, we first have to test if users are able to recognize the personality of the agent (H1) and to identify the goals of the agent in conversation (H2). Moreover, we need to test if the users find the agent believable while communicating (H3).

6.4 Method

This section will describe the method used for evaluation. We describe the participants and the procedure of the study case.

6.4.1 Participants

Participants were 12 users. The selection of participants considered their fluency in English (since the agent communicates in English) and their previous knowledge on Embodied Conversational Agents. Among the participants, 75% (9 participants) were fluent English speakers while 25% were advanced English speakers (3 participants). Participants were both Brazilians and Americans. Brazilian participants participated on a previous interview session to check their English proficiency. Regarding previous knowledge about ECAs, 58,3% (7 participants) reported previous knowledge about conversational agents while 41,6% (5 participants) reported no previous knowledge. Previous knowledge about conversational agents involve previous interaction with such agents in other applications or websites. However, before effectively participating in the case study, participants with no previous reported knowledge were introduced to the subject in order to understand the particularities of such agents (we will describe this previous step in next sections).

6.4.2 Procedure

The study was implemented in different steps. First, participants were interviewed individually in order to verify their English knowledge. This first interview was used to select participants for the study case and therefore is not considered part of the procedure since many interviewees had to be cut off in this step. Interviews were conducted by an English teacher. After, the overall procedures were as follows:

- Participants were interviewed in order to check their previous knowledge about ECAs. This interview took place individually and participants were asked general questions about such agents (Do you know what a conversational agent is? Have you ever interacted with a conversational agent before? Where? How many times?). Interviews about previous knowledge were also conducted in English.

- Participants were introduced to the experiment procedure and were given a brief introduction about conversational agents. Participants with no previous interaction or knowledge were then given time to chat with other conversational agents on the web (they were free to search the Internet for agents). Although the agents they interacted with in this phase did not talk about the same subject that the one developed in this thesis, the experience helped them to understand how to interact with agents and to prepare for the study case. Interaction was free (meaning no established interaction topics). The interaction part of the experiment were not supervised in any means and no questions were made about believability of other agents.

- All participants interacted with all facets of personality of the agent. Each participant played between 5 and 10 games. Some participants decided to play more than one game with the same personality facet of the agent just to have opportunity to interact more. Participants were limited to a maximum of 10 games. The first 5 games involved each 5 different facets of personality while in other games the participants could choose the personality facet they wanted to interact with. This part of the study will be referred as a session in the rest of the document. Sessions were conducted in different days. After participating on a game, participants were given specific agent evaluation questionnaires. After the whole session (after 5 to 10 games), participants were also given an overall questionnaire. Details on the given questionnaires can be found in next sessions.

- The questionnaires were analyzed together with usage data (log files). Log files were important to verify the attitudes of agents that were displayed during each interaction.

6.4.3 Questionnaires

Two questionnaires[1] were used in our study case: an agent evaluation questionnaire (AEQ) and an overall questionnaire (OQ). The AEQ was intended to evaluate each agent individually while the OQ evaluated the agents only after interaction with all facets of personality.

The AEQ was composed of questions that tried to verify the hypothesis that the players would recognize the personality of agents (questions 2,3, and 5) and would identify goals in conversation (question 8). Also, questions were designed to verify the believability of the agent by checking the affective aspect of conversation (questions 1,4, and 7). Questions 6, 9, and 10 were intended to complement participant opinions and to provide extra space for comments. Believability of agent was measured through the affective manifestation of the agent. In our specific scenario, believability was measured using the following rules:

- If the participants agreed that the agent was manifesting emotions according to the chosen personality;
- If the agent was able to elicit an emotional response from participants.

The OQ was composed of questions that tried to differentiate and compare all 5 personality facets. The questionnaire was composed of only 5 questions and participants should relate agents to each behavior listed. They were free to relate the same agent to more than one behavior or to leave agents without classification (or even to skip questions if they felt no agent fit the behavior). The data of the questionnaire was later used to confirm or not the individual agent evaluation questionnaires.

6.5 Results and Discussions

Table 6.2 presents the answers of the participants regarding question 1 of agent evaluation questionnaire (Do you believe this agent is capable of demonstrating emotions and personality?).

Table 6.2: Results Question 1 (AEQ)

Do you believe this agent is capable of demonstrating emotions and personality?

Agent	Personality	A: Yes	A: No
A1	Openness	10	2
A2	Conscientiousness	10	2
A3	Extroversion	12	0
A4	Agreeableness	11	1
A5	Neuroticism	12	0

The majority of the participants were able to recognize some personality or emotional characteristics on agents they interacted with. These results show that we achieved our goal of creating expressive agents based on personality facets. Next sections will discuss the results according to our hypotheses. In order to expose results, agents were assigned specific identification strings: A1 (openness agent with high scores on feeling facet), A2 (conscientiousness agent with high scores on competence and deliberation facets), A3 (extrovert agent with high scores on warmth facet), A4 (agreeableness agent with high scores on altruism), and A5 (Neurotic agent with high scores on self-consciousness).

[1]Both questionnaires can be found later on the document

H1: Users ability to recognize the personality of the agent they are interacting with

Table 6.3 present the answers of the participants regarding question 2 of agent evaluation questionnaire (What kind of personality do you think this agent has?). According to our results, users are not able to name specific personality traits or facets. Instead, they constantly used adjectives that represent some tendency in personality behaviors. Also, some adjectives were assigned to more than one personality facet agent (e.g. friendly, emotive).

Table 6.3: Results Question 2 (AEQ)

What kind of personality do you think this agent has?

Agent	Personality	Answers
A1	Openness	emotive, inconstant, happy
A2	Conscientiousness	confident, secure, careful, motivated
A3	Extroversion	talkative, curious, friendly, extroverted, social, emotive
A4	Agreeableness	helper, friendly, loving, nice
A5	Neuroticism	nervous, preoccupied, stressed, neurotic, insecure, crazy, hard-to-deal-with

Adjectives assigned to agents show that in general, participants were able to associate each specific agent with the correct personality. Table 6.4 presents some of the reasons given by participants to assign a specific personality adjective to an agent (How is this personality expressed?).

Table 6.4: Results Question 3 (AEQ)

How is this personality expressed? (some answers)

Answer	Reasons
Inconstant	Sometimes the agent was happy and then suddenly not anymore
Confident	The agent was always telling me we could do it together
Secure	He seemed very secure about us playing the game
Careful	Because he advised me to think before placing numbers
Motivated	He wanted me to win. He cheered me when I was right.
Curious	He just kept asking questions about me
Social	I felt he enjoyed talking to me
Loving	The agent really wanted to help me play the game
Nice	Se offered help a lot
Preoccupied	He was preoccupied all the time. I could see in his face.
Crazy	You know, like in Portuguese we say: "mania de perseguição"
Insecure	He was always thinking about what others might think
Hard-to-deal-with	He was just very obnoxious in my opinion

Although some adjectives were assigned to different personality facets, in general, they reflected the lack of knowledge about theories of personality. A1 (openness agent with feeling facet) was viewed as emotive and inconstant which means the agent was expressing specific emotions according to his feelings. A2 (conscientiousness agent with high scores on competence and deliberative facets) was assigned with adjectives like confident, secure, and motivated. A3 (extrovert warmth agent) was assigned with adjectives representing the intention of interacting. The same happenned with A4 (agreeableness with high scores on altruism) and A5 (neurotic self-

consciousness agent) who were assigned with adjectives relating to showing an agreeable and helpful behavior and relating to expressing a neurotic behavior, respectively.

Question 5 tried to clarify what personality the users felt the agent demonstrated by presenting some words that were assigned to each personality facet agent. Results are as shown in table 6.5.

Table 6.5: Results Question 5 (AEQ)

Words you think that relates to (or represent) the agent you just interacted with

Agent	Personality	Answers
A1	Openness	agreeable, warm, extroverted, open
A2	Conscientiousness	agreeable, considerate, calm
A3	Extroversion	agreeable, talkative, curious, considerate, warm, extroverted
A4	Agreeableness	agreeable, helpful, emotive, cooperative, considerate, warm
A5	Neuroticism	emotive, unkind, moody, neurotic, nervous, insecure

One can see that when trying to clarify personality types for users, results are not as good as expected. All agents except the neurotic one were considered agreeable, for example. Also, all agents except the extrovert agent were considered emotive. The openness agent with high scores on feelings was considered extroverted by one participant (8,3%).

In conclusion, our experiment showed that **users were able to recognize some of the personality of the agent they were interacting with**. The neurotic and extrovert chosen facets were easily recognized by participants. Agreeableness and conscientiousness facets were not as easily recognizable, but they were somehow recognizable. In fact, if we take into consideration the overall questionnaire (OQ) results, the openness personality facet was the only one that was not recognizable in the comparison between other agents. Users felt the neurotic agent as being the one that expressed emotions more openly (table 6.6 shows the results of the overall questionnaire - only the top voted agent inside each category is shown). When questioned which agent manifested emotions more openly, only 3 responses (25% of total participants) were associated with the openness agent with high scores on feelings.

Table 6.6: Results Questionnaire 2 (OQ)

Question	Answer	Percentage
More extrovert?	A3 (extroversion)	91,6% (11 responses)
Willing to help?	A4 (agreeableness)	100% (12 responses)
More neurotic?	A5 (neuroticism)	100% (12 responses)
Emotions openly?	A5 (neuroticism)	41,6% (5 responses)
Recognized user capacity?	A2 (conscientiousness)	75% (9 responses)

Although question 5 did not help clarifying results presented in previous questions, adjectives participants assigned to agents represented, in general, the characteristics of personality facet behaviors. We believe that question 5 represented a challenge because some of the words presented do not have very specific personality related meanings (e.g. the meaning of agreeable is being pleasant according to dictionaries). Users may have found all agents agreeable to interact without really thinking of agreeableness as a personality trait.

H2: Users ability to identify the goals of the agent in conversation

Table 6.7 present the answers of the participants regarding question 8 of agent evaluation questionnaire (Check if you believe the sentence true. You can check as many sentences as you

like.).

Table 6.7: Results Question 8 (AEQ)

Check if you believe the sentence true

Sentence	Answers
I believe the agent was trying to become friends with me	A3 (91,6%)
I believe the agent was happy to help me.	A4 (100%)
I believe the agent was very nervous.	A5 (100%)
I believe the agent was constantly worried about others	A5 (100%)
I believe the agent was very emotive.	A1 (16,6%)
I believe the agent was very supportive.	A4 (58,3%)
I believe the agent wanted to encourage me.	A4 (83,3%)
I believe the agent believed my capacity to finish the game successfully	A4 (75%)

According to our results, **the identification of goals in conversation is successful, except for the openness agent with high scores on feelings**. We believe the reason behind this exception is the fact that, in our model, this facet is the only one with a more generic goal (since other agents also express emotions according to the events that happen) and therefore it is not easy for users to recognize the hidden goal of expressing emotions.

H3: Believability of the agent

Initially, in our agent evaluation questionnaire, two questions were associated with the H3 hypothesis (test if the users find the agent believable while communicating): question 4 (Does the agent elicit an emotional response from you?) and question 7 (What kind of emotions do you think this agent was experiencing while interacting with you?). Table 6.8 shows that the majority of interactions elicited some emotional response in users.

Table 6.8: Results Question 4 (AEQ)

Does the agent elicit an emotional response from you?

Agent	Personality	A: Yes	A: No
A1	Openness	9	3
A2	Conscientiousness	10	2
A3	Extroversion	12	0
A4	Agreeableness	11	1
A5	Neuroticism	12	0

As already explained, believability in our agent was measured following some rules: (1) if the participants agreed that the agent was manifesting emotions according to the chosen personality; and (2) if the agent was able to elicit an emotional response from participants. Regarding rule 1, we believe that participants agreed that the agent was manifesting emotions according to the chosen personality since the emotions described corresponded to the log files. Considering the case of agreeableness agent, for example, the emotion sadness was believed to be present when users constantly did not accept help from the agent. Regarding rule 2, results show that, in general, agents were able to elicit emotional responses from participants. Users reported all kind of emotions while interacting with agents (happiness, irritation, confusion, pity...). Therefore, according to our experiment, **users found the agent believable while communicating**.

Table 6.9 shows the kind of emotion users believed the agent experienced during interactions.

Table 6.9: Results Question 7 (AEQ)

What kind of emotions do you think this agent was experiencing?

Agent	Personality	Answers
A1	Openness	happiness, sadness, impatience, frustration
A2	Conscientiousness	happiness
A3	Extroversion	happiness
A4	Agreeableness	happiness, sadness
A5	Neuroticism	fear, stress, tension, sadness

6.6 Limitations

Although having a small population for test purposes, our results show the potential of our approach. Limitations on the adopted procedure involved the fact that participants were interviewed and instructed individually mainly because of availability issues. Also, the limitation in the number of participants can be justified by the fact that the whole procedure (from interview to game session) took several days and some participants were not willing to cooperate for that long. Moreover, sessions alone took a lot of time (around 1 and a half hour).

6.7 Final Considerations

The purpose of this chapter was to present our study case used to validate the developed prototype. We first presented some literature about ECAs evaluation and discussed their requirements. After, we discussed the evaluation strategies adopted in this work. Moreover, we described our study case method and presented the results. In our approach, we intended to follow some guidelines on evaluation that we exposed in our discussion. However, a full evaluation was not done due to some limitations. Next section will present our conclusions and future research endeavors. Among the future research endeavors, more complex and comprehensive evaluation strategies are planned.

7 CONCLUSIONS AND FUTURE ENDEAVORS

This work presented our approach trying to enhance affective communication in ECAs. In chapter 1, we contextualized the research area and explained the challenges of the field. We presented our motivation to do research in this area and introduced the PRAIA project. We discussed some taxonomies of the field in order to help understanding the amount of work necessary to develop a full ECA (chapters 1 and 2). We explored how to communicate affectively using ECAs and explained the importance of personality in affective communication.

After, in chapter 3, we explored literature concerning dialogue in conversational systems. We presented characteristics that differ dialogue from other kinds of discourse. We briefly discussed dialogue management in conversational agents. Moreover, we presented the belief, desire, and intention model that was used to manage dialogue in our agent. The same chapter presented an expressive conversational language also used in this work.

Later, in chapters 4 and 5, we introduced our model and our agent implementation. We explained our approach for defining and implementing an Embodied Conversational Agent with cognitive abilities that consider mental aspects of personality and emotion for enhancing affective communication with the user. Finally, chapter 6 presented the evaluation of the developed prototype. We first studied literature about ECAs evaluation in general. Later, we discussed the specific evaluation strategy adopted in this work and presented our results.

This chapter will present our final considerations. We will start by presenting our contributions in section 7.1. Section 7.2 will present the scientific publications generated by our work and will demonstrate the importance of the field by showing examples of conferences related to the topic. Section 7.3 will identify considerations for future research.

7.1 Contributions

Chapter 1 presented our research objectives in order to advance the state of the art and enhance affective communication in ECAs. Now we will briefly comment our work towards achieving our goals before listing our contributions.

As explained in previous section, we performed an extensive study of literature regarding ECAs and affective communication. This effort is shown throughout this document and this comprehensive study fulfilled our objective of providing background literature regarding Embodied Conversational Agents and Affective Communication. We have also developed agents able to show distinct personality facets that influence affective communication. Our efforts to do so are described in chapters 4, 5, and 6.

Therefore, we believe we have achieved success in defining and implementing an Embodied Conversational Agent with cognitive abilities that consider mental aspect of personality for enhancing affective communication with the user. Lastly, the study of literature combined with our motivation and the development of our agents helped us to understand the relation of personality facets and attitudes in dialogue.

Considering the taxonomy of the research areas contributing to the creation of ECAs presented

in chapter 1 (ISBISTER; DOYLE 2004), we contributed in the *believability* category by performing research on how to create the "illusion of life" for those who engage with an ECA. In our opinion, we tried to study and imitate some qualities that are present in (and that influence) human communication (emotion and personality) that will help engaging a person's belief that the agent is an animate creature. We specifically focused on the second class of believability problems: making the intentionality of the agent believable by presenting an approach that used an expressive conversational language with formally defined conversational acts to allow agents to express their feelings and their attitudes (according to their personality).

Inside PRAIA project, our work contributed by trying to present an approach that can be used to try to answer the specific proposed research question *How to respond appropriately to student's emotions?*. We followed the proposed activities of the project since we analyzed and studied the existing literature regarding emotions and affective communication in ECAs, we defined a new approach for enhancing affectivity in human-machine communication. We developed a prototype (agents with different personality facets) using the literature and knowledge acquired during the first part of the project.

Another contribution of our work innovates the manner in which our group works with affectivity in human computer interaction. Previous works inside the group adopted an approach of creating pedagogical agents to be placed inside specific intelligent tutoring systems. The PhD thesis of Jaques (JAQUES 2004), for example, focused on defining and modeling an animated pedagogical agent, Pat, to be placed in a specific environment called MACES (JUNG et al. 2002). The work in this thesis advances the knowledge of the group in agents because it adopts a new top-down strategy that can be used in the future to provide means for creating new and improved pedagogical agents that can fulfill expectations of the users. Although we decided to conduct this thesis differently from traditional works of the group, our intention is not to state which is the best approach to create pedagogical agents.

Combining all specific contributions, we believe we achieved success trying to advance the state of the art on the field. We presented and tested an innovative approach to model verbal communication in ECAs and shared our research efforts and conclusions.

7.2 Scientific Production

Ideas and partial results while developing this work were published in several conferences and workshops (scientific production achieved during the development of this dissertation can be found in detail in appendix A):

- *International Conference on the Design of Cooperative Systems (COOP)* 2008
- *Speech and Face-to-Face Communication Workshop - (SFFC)* 2008
- *Colóquio em Informática Brasil/INRIA* 2009
- *AAAI/SIGART Doctoral Consortium* 2010.

This production highlights the importance of doing work in this field. Leading AI scientific conferences held workshops and special tracks dedicated to the development of ECAs in the past 5 years:

- Workshop on AI for human computing - *International Joint Conference on Artificial Intelligence - IJCAI* 2007
- Special track on virtual agents - *International Conference on Autonomous Agents and Multiagent Systems - (AAMAS)* 2008

- Workshop about standard markup languages for embodied dialogue acts - *International Conference on Autonomous Agents and Multi-agent Systems - (AAMAS)* 2009
- Workshop about interaction with ECAs as virtual characters - *International Conference on Autonomous Agents and Multi-agent Systems - (AAMAS)* 2010

One important conference on the topic is the *International Conference on Intelligent Virtual Agents -(IVA)*. IVA is the major annual meeting of the intelligent virtual agents community, attracting interdisciplinary minded researchers and practitioners from embodied cognitive modeling, artificial intelligence, computer graphics, animation, virtual worlds, games, natural language processing, and human-computer interaction.

7.3 Future Work

While we did our best to enhance affective communication in ECAs, we do not claim that our work is closed. In fact, we intend to keep contributing to this challenging research field in several ways. Therefore, we want to conclude with the following recommendations for future work:

- Perform an experiment trying to study how people behave in communication in order to identify different hidden conversational goals according to different personality facets and situations. This work could be done by using a survey to collect information from participants and to obtain a general view of some population. After, other personality facets could be modeled using this approach.
- Provide the agent with affective tactics to improve learning and contribute to the studies of the influence of personality in pedagogical agents. Also, the adaptation of an agent modeled using our approach in an educational scenario could help verifying the contributions for the PRAIA project.
- Add other variables to the model trying to provide more believability for the agent (for example, consider the emotional model of the player).
- Work on the input and output limitations of the agent, trying to provide open natural language communication.
- Improve the evaluation of the system by designing different experiments that can overcome the limitations we encountered so far.

With this research, we hope to improve the understanding on how ECAs with expressive and affective characteristics can establish and maintain long-term human-agent relationships.

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APPENDIX A - SCIENTIFIC PRODUCTION

This appendix presents the scientific production achieved during the development of this dissertation.

A.1 Papers

1. **Michelle Denise Leonhardt** ; Edilson Pontarolo; Patrícia A. Jaques; Sylvie Pesty; Rosa M. Vicari. Towards an Affective Embodied Conversational Agent for Collaborative Educational Environments. Workshop Affective Aspects of Cooperative Interactions - 8th International Conference on the Design of Cooperative Systems, 2008, Carry-le-Rouet, France. pp. 7-14.

    - This paper presents the scope of the PRAIA project showing partial work of members of the Brazilian group (Michelle Leonhardt and Edilson Pontarolo). Describes how an Embodied Conversational Agent can benefit from the use of an affective model (showing and explaining the affective model developed by Dr. Edilson). It also shows the language being used as a basis for the development of the agent (Michelle's work). This publication demonstrates the integration of research between groups of both countries (France and Brazil) since the language being used in the agent was initially standardized by the French group.

2. **Michelle Denise Leonhardt**; Sylvie Pesty; Rosa. M. Vicari. Towards Expressive Communication in Embodied Conversational Agents. Speech and Face-to-Face Communication Workshop, 2008, Grenoble, France. Proceedings of Speech and Face-to-Face communication Workshop, 2008. pp. 49-51.

    - This paper summarizes the general idea of the agent being developed, briefly detailing the scenario and expected behavior of the agent. The article also briefly describes how the agent will demonstrate affective behavior.

3. **Michelle Denise Leonhardt**; Rosa M. Vicari; Sylvie Pesty. Enhancing Affective Communication in Embodied Conversational Agents. COLIBRI - Colóquio em Informática Brasil/INRIA - Cooperações, avanços e desafios, 2009, Bento Gonçalves, Brazil. Proceedings of XXIX Congresso da Sociedade Brasileira de Computação, 2009. p. 190-194.

    - This paper briefly presents an overview of the agent and contextualize the work inside PRAIA project. Because of the characteristics of the colloquium, this paper was written to demonstrate the integration of research between groups of both countries (France and Brazil).

4. **Michelle Denise Leonhardt** Enhancing Affective Communication in Embodied Conversational Agents. Fifteenth AAAI/SIGART Doctoral Consortium, 2010, Atlanta, USA. Proceedings of the Twenty-Fourth AAAI Conference on Artificial Intelligence (AAAI-10), 2010. v. 3. pp. 1986-1987.

    - This thesis summary outlines the motivation for this dissertation, the proposed plan for research, and a description of the progress to date. Application packet also included: curriculum vita, letter of recommendation from advisor, and a letter explaining the participant's expectations about the conference and the doctoral consortium.

APPENDIX B - AGENT EVALUATION QUESTIONNAIRE

Thank you for participating in this study case. We appreciate your honesty and willingness to assist with this research. As you already know, this is the fourth (and last) part of the overall experiment. For this part, you will be able to interact with an embodied conversational agent we have designed. This agent will act as a companion while you play a sudoku game. He will interact with you while you play.

If you have any questions, please ask the supervisor and they will be answered. We appreciate your help and candidness in answering these questions.

1. Do you believe this agent is capable of demonstrating emotions and personality?
☐ Yes
☐ No

2. What kind of personality do you think this agent has?

3. How is this personality expressed? (What kinds of behavior or words and sentences does the agent exhibit that expresses his personality?)

4. Does the agent elicit an emotional response from you? If so, what kind?

5. Check the words you think that relate to (or represent) the agent you just interacted with. You can check as many words as you like.
☐ Agreeable
☐ Cooperative
☐ Considerate
☐ Warm
☐ Helpful
☐ Tactful
☐ Responsible
☐ Organized
☐ Systematic
☐ Hardworking
☐ Extroverted
☐ Talkative

☐ Relaxed
☐ Calm
☐ Stable
☐ Open
☐ Emotive
☐ Curious
☐ Rude
☐ Unkind
☐ Impulsive
☐ Irresponsible
☐ Careless
☐ Reserved
☐ Introverted
☐ Quiet
☐ Shy
☐ Moody
☐ Neurotic
☐ Nervous
☐ Insecure

6. Is there any other word do you think that can describe the agent (and was not listed above?). Please write (if any).

7. What kind of emotions do you think this agent was experiencing while interacting with you? Why?

8. Check if you believe the sentence true. You can check as many sentences as you like.
☐ I believe the agent was trying to become friends with me.
☐ I believe the agent was happy to help me.
☐ I believe the agent was very nervous.
☐ I believe the agent was constantly worried about others
☐ I believe the agent was very emotive.
☐ I believe the agent was very supportive.
☐ I believe the agent wanted to encourage me.
☐ I believe the agent believed my capacity to finish the game successfully
☐ None of the above

9. Would you be interested in playing more games with this agent as your companion?
☐ Yes
☐ No

10. Any other comments?

APPENDIX C - OVERALL QUESTIONNAIRE

Thank you for participating in this study case. We appreciate your honesty and willingness to assist with this research.

Now that you have interacted with 5 different agents, please answer the questions below. Use numbers to differentiate them: from A1 (the one you first interacted with) to A5 (the last one you interacted with). Please remember you don't need to associate different agents to different questions.

1. Which agent do you think is more extrovert?

2. Which agent do you think is more willing to help?

3. Which agent do you think is more neurotic?

4. Which agent do you think expressed emotions more openly?

5. Which agent do you think recognized your capacity to be successful in the game?

APPENDIX D - RESUMO - PORTUGUÊS

Melhorando a comunicação afetiva em Agentes Conversacionais Incorporados através de um modelo de objetivos de comunicação ocultos baseados em personalidade

D.1 Resumo

Agentes Conversacionais Incorporados (ECAs) são entidades de software que se comunicam em linguagem natural e que possuem uma representação. Seu objetivo é o de exibir comportamento semelhante ao humano na forma como se comunicam. Desenvolver um ECA exige, portanto, entender que aspectos como personalidade, emoções e aparência são extremamente importantes. Este trabalho busca aumentar a credibilidade em tais agentes através do uso de personalidade como ponto central da interação entre humanos e agentes. É proposto um modelo que relaciona facetas de personalidade com objetivos ocultos de comunicação que influenciam as atitudes de um ECA. O artigo descreve também a aplicação do modelo em agentes que interagem em um jogo estilo "puzzle".

D.2 Introdução

Agentes conversacionais incorporados (ou, em inglês, Embodied Conversational Agents - abreviados na literatura como ECAs) podem ser definidos como entidades de software dotadas de uma representação visual que utilizam, em tempo real, diversos canais verbais e não verbais para simular a comunicação humana face a face. A pesquisa em tais agentes, de um modo geral, busca produzir agentes inteligentes capazes de demonstrar comportamento social utilizando sua representação visual de maneira a reforçar a crença de que se tratam de uma entidade social capaz de comunicação e pensamento [1]. O objetivo dos pesquisadores da área é o de criar agentes que possam interagir de forma cada vez mais natural e simples aos olhos do usuário humano.

No prefácio do livro dedicado ao tópico, Ruttkay e Pelachaud [2] discutem o fato de que os grupos de pesquisa atualmente não dispõem de todos os recursos necessários para implementar soluções adequadas a todos os aspectos envolvidos na construção e desenvolvimento de um ECA. Considerando todas as características necessárias para o desenvolvimento de um agente conversacional incorporado completo (representação visual, reconhecimento dos canais de entrada em uma comunicação, processamento e inteligência, modelo de personalidade e emoções, expressão em canais de saída de comunicação) é natural concluir que o desenvolvimento de tais agentes representa um desafio para a comunidade envolvida.

Uma das principais dificuldades enfrentadas pela comunidade acadêmica é a descrição ainda vaga do problema que os pesquisadores desejam resolver. Muitas questões de pesquisa podem ser levantadas quando do desenvolvimento de um agente desse tipo fazendo com que o problema de pesquisa geral ainda não esteja consolidado. Podemos encontrar na literatura um esforço para a criação de taxonomias e definições que podem ajudar pesquisadores a contextualizar seus trabal-

hos.

Isbister e Doyle [1], por exemplo, apresentam uma taxonomia das áreas de pesquisa que colaboram para a construção desses agentes. Eles argumentam que existem pelo menos duas razões para a criação da taxonomia. A primeira é para que seja feita uma distinção mais clara entre as áreas de pesquisa envolvidas de forma que os pesquisadores possam indicar onde estão apresentando contribuições efetivas e onde não estão. A segunda é de que uma taxonomia pode auxiliar na criação de métricas de avaliação para cada área específica. A taxonomia proposta pelos autores é descrita abaixo:

- Credibilidade $\rightarrow$ pesquisa em como criar ilusão de vida para aqueles que observam e interagem com um agente conversacional incorporado. O método comumente usado nessa área é o de imitar e melhorar algumas qualidades dos humanos que farão com que os usuários acreditem estar interagindo com uma criatura viva. A pesquisa em tal categoria pode ser dividida em duas classes: dar credibilidade para a aparência do agente (considerando voz e movimentos, por exemplo) ou dar credibilidade para a intencionalidade do agente (considerando ações e reações que criam a impressão de uma entidade independente com sentimentos e objetivos).

- Sociabilidade $\rightarrow$ pesquisa que foca em produzir melhores interações sociais entre agentes conversacionais incorporados e usuários. Os autores afirmam que o objetivo é o de gerar teorias e técnicas que possibilitam a criação de melhores interações. Essa linha de pesquisa busca inovar a maneira com que os humanos interagem com ECAs e inclui habilidades conversacionais, reações apropriadas e adaptações de comportamento, conhecimento do contexto social da interação (físico ou cultural), empatia, entre outros.

- Tarefas e domínio de aplicação $\rightarrow$ pesquisa que abrange a criação de ECAs capazes de realizar tarefas em domínios específicos como educação, saúde, vendas e outros. O ponto principal dessa linha e que a difere das demais é que a pesquisa deve ter alvos bem definidos e deve começar a partir do domínio de aplicação em que o agente pode acrescentar valor. Os esforços são direcionados primeiramente a entender o domínio de aplicação e suas nuances para depois desenvolver um agente capaz de desempenhar um papel importante dentro de tal domínio.

- Questões computacionais e agentes $\rightarrow$ pesquisa que se concentra na criação de algoritmos, sistemas, arquiteturas e frameworks para o controle de ECAs. Os autores explicam que os esforços nessa área tendem a focar em sistemas que fazem uma troca entre credibilidade e métricas tradicionais de sucesso em sistemas computacionais (como otimização) ou na criação de mecanismos de controle a raciocínio que simulam o comportamento humano de maneira que se possa permitir uma interação mais natural.

Este trabalho se enquadra na primeira categoria da taxonomia apresentada e propõe o uso de traços de personalidade como forma de aumentar a credibilidade de agentes conversacionais incorporados. O objetivo maior do trabalho está em colocar a personalidade como ponto central da interação verbal entre humanos e agentes de forma a facilitar a comunicação afetiva entre os mesmos. Cabe ressaltar que, apesar de estarmos utilizando a taxonomia proposta pelos autores como forma de classificar a contribuição do trabalho apresentado, tal taxonomia ainda não é completamente aplicável já que a pesquisa em uma área pode influenciar e interferir em outra (ex. aumentar a credibilidade do agente através de sua intencionalidade usando algum aspecto afetivo e, conseqüentemente, desenvolvendo um mecanismo de raciocínio para lidar com o aspecto considerado).

Através deste trabalho procuramos apresentar e testar uma alternativa inovadora para modelar a comunicação verbal em ECAs de forma a aumentar sua credibilidade e facilitar a comunicação afetiva entre agentes e humanos. Para isso, apresentamos um modelo que relaciona facetas de

personalidade e objetivos de comunicação ocultos. De acordo com o modelo proposto, a comunicação verbal de um agente é influenciada por sua personalidade através de objetivos ocultos que, apesar de sofrerem influência do contexto em que a conversação ocorre, são independentes de tópico de conversação e tarefas executadas.

Com o objetivo de testar o modelo proposto, desenvolvemos diferentes agentes (dotados com diferentes personalidades) capazes de interagir com usuários em um jogo de SUDOKU. Os agentes desenvolvidos utilizam de atos de fala expressivos [3] e uma abordagem baseada em crenças, desejos e intenções [4][5] para o desenvolvimento de uma comunicação escrita (não é considerado o uso de voz) que possa se aproximar mais da comunicação natural entre humanos.

D.2.1 Projeto PRAIA

O trabalho proposto está inserido no âmbito do projeto PRAIA. O projeto PRAIA (Pedagogical Rational and Affective Intelligent Agents) busca desenvolver metodologias, modelos, ferramentas e soluções que considerem as emoções dos alunos na interação com o tutor.

Alguns pontos importantes de interesse do projeto incluem:

- Como modelar e respresentar as emoções dos alunos?
- Como reconhecer as emoções dos alunos?
- Como responder apropriadamente aos alunos?

Para responder tais questões, algumas atividades definidas para o projeto incluem:

- Analisar e estudar os métodos existentes para reconhecimento, modelagem e expressão de emoções;
- Criar e explorar novos métodos e técnicas para reconhecimento, modelagem e expressão de emoções;
- Desenvolver protótipos usando os métodos e técnicas desenvolvidos pelos grupos de pesquisa e pesquisadores envolvidos.

Dentro do projeto, o desenvolvimento e criação de um agente conversacional incorporado que apresente características emotivas, de forma a permitir sua intergração em ambientes colaborativos é de grande importância, uma vez que permite adaptar os sistemas educacionais inteligentes à afetividade do aluno, buscando a adequação do ambiente de ensino e aprendizagem ao mesmo, considerado sob aspectos cognitivos e afetivos.

D.3 Personalidade e Credibilidade em ECAs

A noção de credibilidade se origina no campo da animação onde credibilidade significa que as pessoas podem sentir que um determinado personagem é real [7]. Em outras palavras, a noção de credibilidade é bastante relacionada com a expressão das características emocionais de um personagem, que, por sua vez, é influenciada pela individualidade do mesmo e também pelo contexto. Com o objetivo de aumentar a credibilidade em ECAs, muitas tentativas são feitas para dar-lhes alguns aspectos afetivos.

Aspectos afetivos são importantes no desenvolvimento de ECAs uma vez que modulam os canais utilizados pelos humanos na comunicação diária: expressões faciais, gestos, postura, tom de voz, respiração e até mesmo temperatura da pele. É natural para o humano expressar afeição utilizando tais modalidades. A literatura atual mostra que o termo "credibilidade" ainda não possui uma definição formal e amplamente aceita. Os autores normalmente concordam, contudo, que determinados aspectos afetivos como personalidade causam impacto na credibilidade de um agente [8].

Essa noção pode ser confirmada pelo trabalho de Niewiadomski, Demeure e Pelachaud [9] aonde os autores conduzem experimentos tentando analisar diferentes fatores que influenciam a percepção da credibilidade em agentes conversacionais incorporados. De acordo com suas conclusões, um agente que usa diferentes canais verbais e não verbais de forma apropriada apresenta maior credibilidade do que um agente que usa somente um ou dois desses canais. Outra conclusão apresentada pelos autores mostra que alguns fatores de individualidade relacionados com a noção de personalidade influenciam na noção de credibilidade de um agente.

A importância de se considerar personalidade como um aspecto que influencia a credibilidade de agentes pode ser resumida com a opinião apresentada no trabalho de Catrambone e colegas [10] onde os autores argumentam que criar um agente conversacional incorporado sem a preocupação com aspectos de individualidade pode não prover flexibilidade suficiente para interações onde comportamento, personalidade, emoção e aparência parecem ser tão importantes. Ruttkay, Doormann and Noot [11] também incluem personalidade como um fator mental importante em sua taxonomia de fatores relevantes para a criação de ECAs.

D.4 Trabalhos relacionados

Bevacqua, Mancini e Pelachaud [12] propõem um sistema que modula o comportamento de um agente passivo através da noção de personalidade. Os autores estão interessados em construir um ECA que possui traços de personalidade reconhecíveis quando interagindo com usuários em um papel mais passivo na conversação (agentes que escutam humanos). Um modelo é proposto baseado em algumas características: (i) a preferência que um agente tem em utilizar diferentes canais de comunicação disponíveis e (ii) um conjunto de parâmetros que afetam o comportamento do agente (uso de gestos amplos ou gestos mais contidos, por exemplo). Essas características são fixadas de acordo com os traços de personalidade do agente, isto é, os autores propõem um sistema em que os traços de personalidade de um agente são usados como forma de determinar as tendências de comportamento de um agente.

Outros trabalhos na literatura que investigam padrões de comportamento de agentes de acordo com traços de personalidade variam de uma abordagem mais genérica que cria modelos para relacionar emoções, comportamentos não verbais e personalidade [13] para abordagens mais focadas que isolam e relacionam modalidades específicas de comunicação e traços de personalidade [14]. Outros trabalhos ainda investigam preferências em aparência e personalidade [15]. Os trabalhos apresentados, de um modo geral, concentram seu foco em canais de comunicação não verbais e sua relação com o comportamento de agentes de acordo com traços de personalidade. O foco do trabalho aqui apresentado, no entanto, está na comunicação verbal e na forma como um agente manifesta características de personalidade nesta comunicação.

Literatura relacionada com o trabalho proposto não é encontrada somente no campo de agentes conversacionais incorporados mas também na área de geração de linguagem natural. O trabalho de Rowe, Ha e Lester [16], por exemplo, propõe um gerador de diálogo baseado em arquétipos (modelos inatos presentes no inconsciente coletivo que servem de base para o desenvolvimento da psique humana) para cenários narrativos. Tais arquétipos definem medos, objetivos, motivações e características de personalidade. De acordo com os autores, os arquétipos são adotados pela sua capacidade de definir conjuntos de comportamentos que são familiares para audiências. O modelo proposto pelos autores emprega gramáticas de unificação probabilísticas que consideram muitas fontes de informação para gerar dinamicamente diálogo apropriado. A diferença de tal abordagem para o trabalho aqui proposto reside no fato de que ao invés de usarmos a noção de arquétipos baseados no trabalho de Schmidt [17], estamos usando um modelo bastante aceito de facetas de personalidade para propor objetivos ocultos de comunicação em nossos agentes.

Um trabalho mais parecido com o trabalho aqui proposto é o de Walker, Cahn, and Whittaker [18] onde os autores introduzem a noção de estilo de improvisação lingüística (ou, em inglês, Linguistic Style Improvisation) que se preocupa com o conteúdo semântico, a forma sintática e a

Table D.1: Facetas da Personalidade (NEO PI-R)

Extroversão	Neuroticismo	Abertura	Conscienciosidade	Amabilidade
Acolhimento	Ansiedade	Fantasia	Competência	Confiança
Gregariedade	Hostilidade	Estética	Ordem	Moralidade
Assertividade	Depressão	Sentimentos	Senso de Dever	Altruismo
Atividade	Autoconsciência	Aventura	Direcionamento	Cooperação
Busca de Sensações	Impulsividade	Ideias	Autodisciplina	Modéstia
Emoções Positivas	Vulnerabilidade	Valores	Deliberação	Sensibilidade

realização acústica como estratégia para produzir uma fala. O trabalho dos autores usa um conjunto de parâmetros (distância social, imagem pública do agente e hierarquia entre interlocutores) para definir o estilo lingüístico de um agente (que, por sua vez, ajuda os interlocutores a definir qual a personalidade dos agentes com quem interagem). Considerando o trabalho apresentado em [18], o trabalho aqui proposto pode ser visto como complementar, uma vez que poderia ser utilizado de alguma forma como outro parâmetro para definição do estilo linguístico introduzido pelos autores. Porém, ao invés da preocupação clara com a forma do que é comunicado, o foco do trabalho aqui apresentado se encontra mais na intenção do agente (objetivos ocultos de comunicação) que influenciam a forma como um agente conversa não somente em uma interação específica, mas em longo prazo em todas suas interações.

D.5 Propondo um Modelo de Objetivos Ocultos de Comunicação Baseados em Facetas de Personalidade

Teorias que descrevem personalidade baseadas em traços introduzem o conceito de que indivíduos diferem em um número pequeno de dimensões que permanecem estáveis durante a vida e as situações. Traços de personalidade, portanto, podem ser definidos como tendências a padrões de pensamentos, emoções e comportamentos que caracterizam seres humanos [19]. O modelo dos cinco grandes fatores de personalidade (também conhecido como Five-Factor Model - FFM) descreve a personalidade humana em termos de cinco grandes dimensões, cada uma reunindo uma variedade de traços psicológicos: extroversão, neuroticismo, abertura à experiência, conscienciosidade e amabilidade [20][21][22]. Cada traço da personalidade pode ser subdividido em seis facetas inter-relacionadas de acordo com o Inventário de Personalidade NEO revisado (NEO PI-R). As facetas são apresentadas na tabela D.1 e ajudam a representar da melhor maneira possível a amplitude e o alcance de cada fator, proporcionando informações mais detalhadas que não estão refletidas no traço temperamental por si só [21].

O modelo de objetivos ocultos de comunicação proposto neste trabalho usa diferentes facetas de personalidade para influenciar a comunicação de agentes conversacionais incorporados. Apesar da existência de 30 facetas passíveis de exploração, foram escolhidas somente as apresentadas na tabela D.2.

Para a concepção do modelo, as facetas de personalidade escolhidas foram relacionadas ao modelo OCC (que leva o nome de seus autores: Ortony,Clore, and Collins)[23]. O modelo OCC determina que as emoções podem surgir a partir da avaliação de três aspectos do mundo: eventos (maneira pela qual as pessoas percebem as coisas que acontecem), agentes (podem ser pessoas, animais, objetos inanimados ou abstrações) e objetos (objetos inanimados). As percepções emocionais são valoradas a partir de seus objetivos (se promovem ou impedem os objetivos e preferências de alguém), padrões e preferências.

Segundo o modelo OCC, as emoções de medo (valência negativa) e esperança (valência positiva) surgem quando uma pessoa foca o quanto um evento é desejável ou não para si no futuro.

Table D.2: Facetas de Personalidade e Comportamentos Associados

Personalidade	Faceta	Descrição
Extroversão	Acolhimento	Descritos como genuinamente interessados em outras pessoas e com tendências a demonstrar sentimentos positivos em relação a seus pares. Tendem a formar relações próximas e íntimas (amizade) rapidamente.
Neuroticismo	Autoconsciência	Descritos como sensíveis sobre as opiniões de terceiros. Apresentam medo de críticas. Tendem a se sentir encurralados e julgados o tempo todo.
Abertura	Sentimentos	Descritos como conscientes de suas emoções. Tendem a expressar emoções abertamente.
Conscienciosidade	Competência	Descritos como disponíveis para ajudar os outros. Encontram nisso conforto e recompensa.
Amabilidade	Altruísmo	Descritos como indivíduos que acreditam que possuem competência para realizar determinada tarefa. Acreditam possuir inteligência e controle necessário.

Dessa forma, a esperança ocorre quando uma pessoa desenvolve a expectativa de que algum evento bom (desejável) irá acontecer e medo quando desenvolve a expectativa de que algum evento ruim (indesejável) irá acontecer. Com base nas emoções de medo e esperança, foram definidos os eventos desejáveis para cada faceta de personalidade (apresentada na tabela **??**) para um agente interagindo no jogo proposto. As facetas de personalidade foram isoladas, ou seja, cada faceta foi considerada sem a influência de outros traços de personalidade e de outras facetas.

Da mesma forma, também foram definidos os objetivos ocultos de comunicação. Os objetivos ocultos de comunicação propostos neste trabalho existem de forma inconsciente (por isso são denominados ocultos) e permeiam todas as interações do agente, independente da tarefa a ser executada. Assim, um agente extrovertido com uma faceta de acolhimento presente apresenta um desejo de estabelecer uma amizade (esperança) e, para isso, irá interagir com o usuário de forma a criar certa intimidade. Ele fará perguntas demonstrando interesse na vida do usuário e demonstrará atitudes positivas em relação ao mesmo. A figura D.1 mostra os demais objetivos ocultos de conversação definidos.

Um agente amável com uma faceta altruísta terá a esperança de ajudar o seu interlocutor qualquer que seja a tarefa em execução (podemos pensar também no caso de um interlocutor contando seus problemas). Um agente consciente e com uma faceta de competência desejará estimular o usuário a conseguir atingir seus objetivos. Na realidade, a faceta de competência foi combinada com a faceta de deliberação. Como o agente competente tem esperança de atingir seus objetivos (e se acredita competente) ele estimulará o seu companheiro na conversação a também fazer o mesmo visto jogar é uma atividade que se faz em conjunto (no exemplo utilizado neste trabalho).

Um agente neurótico com uma faceta de autoconsciência terá o medo de ser julgado e, portanto, tentará justificar todos os seus atos falhos em uma determinada situação em que estiver inserido. Por fim, um agente aberto e com uma faceta de sentimentos buscará simplesmente aproveitar a situação com esperança de viver seus sentimentos em profundidade.

Apesar dos objetivos terem sido definidos de acordo com o jogo usado para testes do modelo, eles podem atender situações mais genéricas. Assim sendo, um agente que possui a faceta de acolhimento em uma personalidade extrovertida buscará (inconscientemente), em suas interações diárias, estabelecer uma amizade com seu interlocutor. Da mesma forma, um agente neurótico com a faceta de autoconsciência evitará julgamentos de terceiros (evitando agir de forma errada ou incorreta perante o grupo em que se insere).

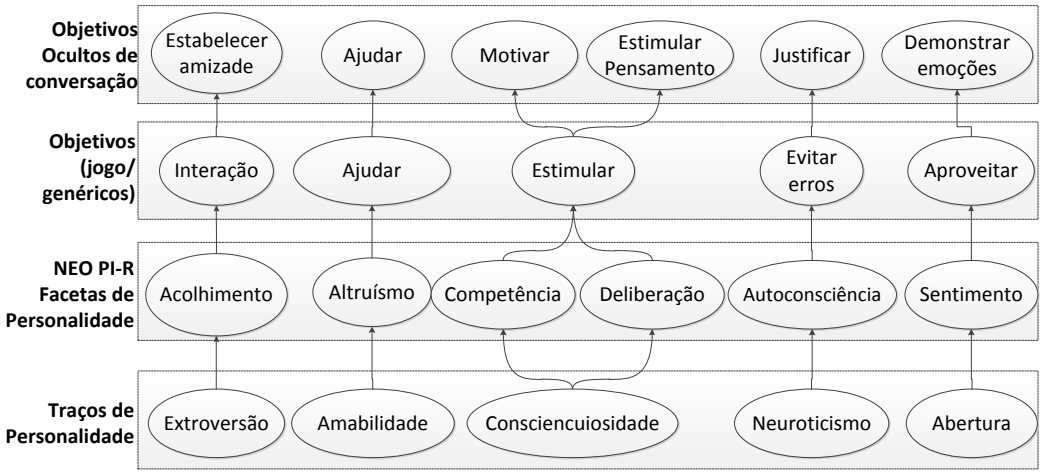

Figure D.1: Modelo de Objetivos Ocultos de Comunicação

Table D.3: Atos de Conversação - Linguagem de Conversação Expressiva

Assertivos	Commissivos	Diretivos	Declarativos	Expressivos
Afirmar	Comprometer	Pedir	Declarar	Agradecer
Negar	Prometer	Perguntar	Aprovar	Desculpar
Pensar	Garantir	Sugerir	Desistir	Elogiar
Dizer	Aceitar	Aconselhar	Anular	Felicitar
Lembrar	Recusar	Requerer		Reclamar
Informar	Renunciar	Mandar		Protestar
Contradizer	Oferecer	Proibir		Cumprimentar

D.6 Aplicando o Modelo Proposto

O modelo de objetivos ocultos de conversação foi aplicado em agentes desenvolvidos utilizando uma abordagem de crenças, desejos e intenções (belief, desire, intentions - BDI) [4][5]. O modelo BDI foi combinado com uma linguagem de conversação expressiva proposta em [3] que formaliza 33 atos de conversação (apresentados na tabela D.3) com suas condições de sucesso e satisfação.

Os agentes desenvolvidos atuam em uma aplicação de jogo de SUDOKU. A aplicação foi desenvolvida de forma que um agente tenha o papel de companheiro do usuário, conversando e reagindo conforme o jogo progride (dependendo da personalidade, o agente pode ou não comentar jogadas erradas, manifestar felicidade ou tristeza, etc).

Os agentes foram modelados para realizar três diferentes tarefas. A primeira tarefa (apresentação) tem como objetivo apresentar o ambiente do jogo e explicar as regras. A segunda tarefa (observação) envolve a observação das jogadas do usuário. A terceira e última tarefa (fechamento) envolve uma interação final com o usuário, comentando o jogo recém finalizado. A influência do modelo de objetivos ocultos de conversação em cada uma dessas tarefas pode variar de diferentes formas. Na tarefa de apresentação, por exemplo, o nível de detalhes dados na explicação pode ser maior ou menor, dependendo da personalidade do agente (no caso de um agente altruísta). A tarefa de observação envolve ou não a intromissão do agente em caso de erros ou acertos do usuário. A tarefa de fechamento é a tarefa onde a emoção de esperança ou medo será ou não confirmada,

fazendo com que o agente utilize diversos atos expressivos para manifestar sua emoção corrente.

Além disso, o comportamento geral do agente será presente em todas as tarefas na forma de seu comportamento verbal corriqueiro. Um agente acolhedor (extrovertido) fará perguntas sobre as preferências do usuário ("Você gosta do jogo?") para tentar estabelecer uma amizade (essas perguntas serão feitas no decorrer de todo o jogo). Um agente neurótico reclamará constantemente e manifestará seu receio em ser julgado (dizendo, por exemplo, "Não é nossa culpa que esse jogo é assim tão difícil!" ou "Se alguém estiver chegando nós podemos sempre clicar no botão limpar e ninguém saberá que cometemos tantas jogadas erradas..."). Outro exemplo é o de um agente competente que irá estimular o usuário a não desistir ou a pensar antes de realizar uma nova jogada (em caso de uma jogada errada, por exemplo).

O comportamento não verbal também é contemplado na implementação. Os agentes desenvolvidos utilizam o toolkit DIVA [1] para definição de aparência e comportamento não verbal apropriado (o comportamento não verbal foi modelado conforme trabalhos existentes na literatura, apresentados na seção de trabalhos relacionados). A figura **??** mostra a interface do jogo desenvolvido juntamente com o agente nela inserido. É importante notar que, apesar dos atos de fala formalizados pela linguagem de conversação expressiva estar aqui listados em português (traduzidos), todo o agente foi desenvolvido para conversar em inglês. Desta forma, a figura **??** apresenta o arquivamento (log) de uma conversação em andamento em inglês (canto direito superior).

De forma resumida, os objetivos ocultos de comunicação propostos no modelo apresentado, juntamente com a formalização de atos de fala propostos na linguagem de conversação expressiva combinada com uma lógica baseada em crenças, desejos e intenções, fornece o mecanismo de raciocínio das intenções comunicativas do agente. Devido às limitações do campo de pesquisa de processamento de linguagem natural e o foco deste trabalho, as sentenças ditas pelo agente foram pré-estabelecidas conforme as intenções comunicativas possíveis e os atos de fala disponíveis. Da mesma forma, as sentenças que poderiam ser ditas pelo usuário também foram pré-estabelecidas e estavam disponíveis em uma caixa de seleção (conforme figura D.2 - canto inferior direito).

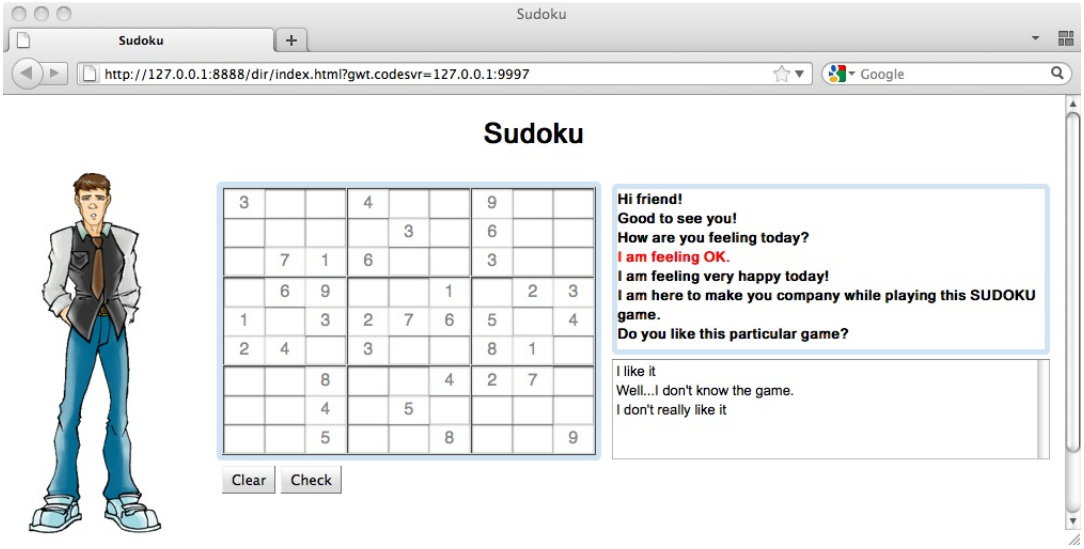

Figure D.2: Cenário de Aplicação e Agente

[1] (http://www.limsi.fr/ jps/online/diva/divahome/)

D.7 Avaliando o Modelo Proposto

A avaliação do modelo apresentado levou em consideração a taxonomia apresentada na introdução através das técnicas de avaliação sugeridas para cada categoria da taxonomia [3]. Foi realizado um estudo de caso para verificar se os usuários interagindo com os agentes seriam capazes de reconhecer ou identificar aspectos de personalidade dos agentes (H1) e se conseguiriam identificar os objetivos de comunicação ocultos através do comportamento do agente - identificando seus medos e suas esperanças (H2). Finalmente, uma última hipótese testada envolveu verificar a credibilidade dos agentes (H3).

D.7.1 Participantes e Procedimento

A seleção dos participantes para teste do modelo (interação com agentes desenvolvidos) considerou a sua fluência no idioma inglês (testes prévios foram feitos para realizar tal verificação) e o seu conhecimento prévio sobre Agentes Conversacionais Incorporados. Foram selecionados 12 participantes dos quais 75% (9 participantes) eram falantes fluentes do idioma inglês e os 25% restantes eram falantes avançados do idioma (participantes envolveram nativos brasileiros e americanos).

Considerando o conhecimento prévio em ECAs, 58,3% (7 participantes) reportaram conhecimento prévio sobre o assunto enquanto que 41,6% (5 participantes) reportaram não possuir tal conhecimento prévio. Foi considerado conhecimento prévio qualquer interação com esse tipo de agentes anterior ao experimento (em outras aplicações ou páginas da internet).

O procedimento de avaliação iniciou com uma entrevista individual (conduzidas por um professor de inglês) a todos os participantes voluntários para verificação de seu nível de conhecimento do idioma inglês. Esse primeiro encontro resultou na exclusão de diversos participantes (inicialmente contávamos com 20 voluntários), uma vez que o conhecimento do idioma era imprescindível para entendimento da conversação. Logo após, os participantes foram novamente entrevistados individualmente para verificar o conhecimento prévio em ECAs.

A próxima fase envolveu a explicação do experimento e uma introdução genérica sobre agentes conversacionais incorporados. Participantes que não possuíam conhecimento prévio tiveram tempo para interagir com outros agentes disponíveis (em páginas da internet). Cabe ressaltar, porém, que o objetivo dessa parte do experimento foi de nivelar o conhecimento prévio dos participantes e, portanto, os mesmos não foram observados ou guiados em sua interação.

Em uma fase final, os participantes interagiram com todas as facetas de personalidade modeladas (sessões de jogo). Para isso, cada participante jogou entre 5 e 10 jogos na companhia de diferentes agentes (diferentes facetas de personalidade cada uma interagindo individualmente em um jogo). Cinco desses jogos eram obrigatórios (por se tratar de cinco diferentes facetas modeladas) e outros cinco jogos eram opcionais (os usuários poderiam escolher jogar mais de uma vez com os agentes de sua preferência).

Ao final de cada jogo os participantes receberam um questionário para reportar a interação recém realizada (que foi chamado de agent evaluation questionnaire - AEQ). Ao final de todos os jogos os participantes receberam um questionário comparativo (overall questionnaire - OQ). Os questionários foram avaliados juntamente com os arquivos de dados da conversação coletados (usage data log). Os dados de conversação permitiram acompanhar as atitudes de cada agente em cada conversação específica, bem como as atitudes dos usuários na conversação.

O questionário AEQ envolveu perguntas que tentavam verificar a hipótese H1 (usuários seriam capazes de reconhecer ou identificar aspectos de personalidade dos agentes) e H2 (identificação dos objetivos de comunicação ocultos através do comportamento do agente). Algumas das questões presentes no questionário também buscavam verificar a credibilidade do agente (hipótese H3). O apêndice B lista as perguntas presentes no questionário AEQ.

A credibilidade do agente foi medida usando os seguintes critérios: (i) os participantes sentiam que o agente manifestava emoções e comportamentos de acordo com a personalidade; (ii) o agente

causava comportamento emocional por parte dos participantes.

O questionário OQ (apêndice C) foi aplicado apenas para confirmar e esclarecer possíveis dúvidas deixadas pelo questionário AEQ e para extrair uma visão geral comparativa entre todas as facetas de personalidade. O questionário OQ apresenta comportamentos previamente descritos (quase como a questão 8 do questionário AEQ) que deveriam ser atribuídos a cada um dos agentes com os quais o usuário interagira (conforme tal comportamento fosse identificado ou não na conversação).

D.7.2 Conclusões

Os experimentos demonstraram que os usuários são capazes de reconhecer algumas das facetas de personalidade dos agentes com quais interagiram (H1). As facetas escolhidas para os traços de extroversão e neuroticismo foram facilmente reconhecidas. As facetas escolhidas para os traços de amabilidade e conscienciosidade foram reconhecidas em menor significância. Levando em consideração os resultados presentes no questionário OQ, a faceta escolhida para o traço de abertura à experiência foi a única que não foi facilmente reconhecida na comparação com outros agentes.

A avaliação dos questionários mostrou que a faceta de sentimentos (traço abertura à experiência) não é facilmente reconhecível uma vez que os sentimentos negativos demonstrados pela faceta escolhida para a personalidade de neuroticismo foram mais evidentes e transparentes que os sentimentos demonstrados pelo agente aberto com faceta sentimental. A mesma conclusão ocorreu para a hipótese H2 (identificação dos objetivos de comunicação ocultos através do comportamento do agente).

Acreditamos que este resultado ocorreu pelo fato de que o objetivo oculto do agente aberto (faceta sentimentos) é bastante genérica e não evidente em um cenário como o cenário testado. O cenário do jogo de SUDOKU envolvia questões como certo e errado (jogada correta ou errada), fazendo com que o objetivo oculto de ajudar ou justificar erros tenha prevalecido para demonstração de sentimentos equivalentes. Um agente aberto demonstra emoções de forma mais genérica e menos associadas a eventos evidentes, portanto, menos perceptíveis em longo prazo.

Em termos de credibilidade (H3) os resultados mostram que os participantes reconheceram o lado emocional e de personalidade da maioria dos agentes (exceto pelo agente aberto à experiência) e que as personalidades/emoções reconhecidas estavam de acordo com o agente com quem interagiam. Da mesma forma, os participantes descreveram diferentes emoções que foram causadas pela interação com os agentes (alegria, irritação, confusão, pena...). Ambas as conclusões mostram que os participantes consideraram os agentes com certo grau de credibilidade.

D.8 Considerações Finais

Este trabalho propôs um modelo de objetivos ocultos de comunicação baseados em facetas de traços personalidade para aumentar a credibilidade em agentes conversacionais incorporados. O modelo aqui proposto foi testado em um cenário de aplicação de jogo de SUDOKU através de diferentes agentes dotados de diferentes facetas de personalidade que interagem com usuários de forma a fazer companhia durante o jogo. A combinação de uma formalização lógica de 33 diferentes atos de fala (linguagem de conversação expressiva) com uma abordagem baseada em crenças, desejos e permitiu desenvolver o controle de diálogo de cada agente conforme o modelo de objetivos ocultos proposto. Dessa forma, o modelo permite uma comunicação mais afetiva entre o usuário e o agente, uma vez que o agente sofre a influência de tais objetivos em todas as suas interações.

Considerando a taxonomia usada como guia para o desenvolvimento desta pesquisa (apresentada na introdução), o trabalho contribui no sentido de propor um modelo diferenciado para aumentar a "ilusão de vida" para aqueles que interagem com tais agentes em diferentes aplicações. O trabalho proposto busca estudar de que forma o aspecto afetivo da personalidade pode influenciar diálogos entre agentes e humanos.

Uma próxima etapa da pesquisa aqui apresentada envolve a definição de objetivos ocultos de comunicação para todas as facetas de personalidade, além de um estudo sobre a combinação de facetas e sua implicação no comportamento de agentes. Dessa forma, o modelo poderia ser expandido e incorporado em outros domínios de aplicação, de forma a aumentar a credibilidade de tal categoria de agentes.

D.9 Referências

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APPENDIX E - RÉSUMÉ - FRANÇAIS

Modèle de communication affective pour agent conversationnel animé, basé sur des facettes de personnalité et des buts de communication "cachés"

E.1 Résumé

Les Agents Conversationnels Animés (ACA) sont des personnages virtuels interactifs et expressifs, dont l'aspect est très souvent "humain", exploitant diffèrentes modalités telles que la face, le langage, les gestes, le regard ou encore la prosodie de la voix. Le but est qu'ils s'expriment en langage naturel et puissent dialoguer avec des interlocuteurs humains. Pour développer un ACA, il faut d'abord comprendre que des aspects tels que personnalité, les émotions et leur apparence sont extrêmement importants. Le travail qui est présenté dans cette thèse a pour objectif d'augmenter l'acceptabilité et la crédibilité des agents au moyen de la personnalité, considérée comme une notion centrale à l'interaction ACA-humain. On propose un modèle qui dote l'ACA de facettes de personnalité et de buts de communication "cachés" et qui module ainsi ses actions conversationnelles. Ce travail présente également une application de jeu de type "puzzle", intégrant un ACA doté de facettes de personnalité et de buts "cachés", qui a servi de support à plusieurs expérimentations et à l'évaluation du modèle proposé.

E.2 Introduction

Les Agents Conversationnels Animés (ACA é ou en anglais ECA - Embodied Conversational Agents -) sont des agents logiciels dotés d'une représentation visuelle, souvent de type personnage, lesquels utilisent en temps réel plusieurs canaux, verbaux et non verbaux, pour communiquer en face à face avec un humain.

La recherche dans le domaine des ACA a pour but principal de concevoir des agents intelligents capables d'exhiber un comportement communicatif acceptable pour l'humain et d'engager de véritables dialogues avec lui, en utilisant les modalités tant verbales que non verbales (face, gestes, regard,é) et en dotant ces agents d'émotions et de personnalité pour renforcer leur crédibilité et leur acceptabilité [1]. L'objectif est donc de créer un nouveau mode d'interaction Humain-Machine, plus naturelle, plus simple pour léutilisateur.

Dans la préface du livre consacré é ce sujet, Ruttkay et Pelachaud [2] discutent le fait qu'il est nécessaire de regrouper de nombreuses compétences scientifiques pour mettre en oeuvre les solutions appropriées à tous les aspects nécessaires é la construction et au développement logiciel d'un ACA. En effet, si l'on considére l'ensemble des caractéristiques nécessaires pour le développement d'un ACA (aspect graphique et animation temps réel, reconnaissance des signaux en provenance de diffèrents canaux d'entrée, modèle de dialogue, modèle de personnalité et d'émotion, expression multimodale,...), il est alors naturel de conclure que le développement de tels agents est un véritable défi.

L'une des faiblesse actuelle est la description encore peu précise de l'ensemble des problèmes à résoudre. On peut trouver dans la littérature plusieurs tentatives de créer des taxonomies et définitions pouvant aider les chercheurs à contextualiser leurs études. Isbister et Doyle [1], par exemple, présentent une taxonomie des domaines de recherche qui doivent collaborer à la construction de ces agents. D'après les auteurs, il y a au moins deux raisons pour la création d'une taxonomie. La première concerne une distinction plus claire entre les domaines de recherche de telle sorte que les chercheurs puissent indiquer où se positionnent leurs contributions. La seconde concerne une taxonomie qui puisse aider dans la création de métriques d'évaluation pour chaque domaine spécifique. Voici quelques uns des aspects essentielsé:

- Crédibilité ⇀ recherche sur la façon de créer "illusion de vie" pour ceux qui observent et interagissent avec un agent conversationnel incorporé. La méthode couramment utilisée est celle d'imiter et améliorer des qualités humaines qui feront les usagers croire qu'ils sont en train d'interagir avec une créature vivante. Ce type de recherche peut être divisé en deux classes: Donner de la crédibilité pour l'apparence de l'agent (en ce qui concerne voix et mouvements, par exemple) ou donner de la crédibilité pour l'intention communicative de l'agent (considérant actions et réactions qui donnent l'impression d'un composant indépendant avec des sentiments et des objectifs).

- Sociabilité ⇀ recherche qui a pour but produire des meilleures interactions sociales entre agents conversationnels incorporés et usagers. D'aprés les auteurs, le but est celui de gérer des théories et techniques qui permettent la création des meilleures interactions. Cette ligne de recherche essaie d'innover dans la façon dont les sujets humains interagissent avec les ECA et inclut des capacités conversationnelles, réactions appropriées et adaptations comportementales, connaissance du contexte social de l'interaction (physique ou culturel), empathie, entre autres.

- Tâches et domaine d'application ⇀ recherche qui comprend la création des ECA capables de réaliser des tâche dans des domaines spécifiques comme éducation, santé, ventes, etc. Le point central de cette ligne de recherche, qui la rend diffèrente des autres, c'est que la recherche doit avoir des cibles bien définies et partir du domaine d'application où l'agent puisse ajouter de la valeur. Les efforts se destinent premièrement é comprendre le domaine d'application et ses nuances et deuxiémement é développer un agent capable de jouer un réle important dans le domaine mentionné.

- Questions computationnelles ⇀ recherche concentrée dans la création des algorithmes, systèmes, architectures et frameworks pour le contréle des ECA. Les auteurs expliquent que les efforts dans ce domaine se concentrent dans des systèmes qui font un échange entre crédibilité et métriques traditionnelles qui ont eu du succés dans des systèmes computationnels (comme optimisation) ou dans la création de mécanismes de contréle du raisonnement qui imitent le comportement humain de façon é permettre une interaction plus naturelle.

Notre travail se situe dans le premier aspect présenté, celui de la Crédibilité, puisque nous proposons l'usage de traits de personnalité comme une façon d'augmenter la crédibilité des agents conversationnels animés et que nous plaéons cette personnalité comme un point essentiel dans l'interaction verbale Humain-ACA. Nous recherchons ainsi une alternative innovante pour modéliser la communication verbale des ACA, de façon à augmenter leur crédibilité et faciliter la communication affective entre agents et humains. Nous présentons un modèle qui relie à des facettes de personnalité de l'agent à des buts de communication dits "cachés". Selon le modèle proposé, la communication verbale d'un agent dépend de sa personnalité qui se matérialisent par des buts qui lui sont propres, les buts "cachés", lesquels, malgré le contexte dans lequel la conversation s'inscrit, sont indépendants du sujet de la conversation et des tâches réalisées.

Afin d'évaluer le modèle proposé, on a développé diffèrentes versions d'agents (dotés de personnalités diffèrentes et de buts "cachés" diffèrents) capables d'interagir avec des usagers dans un jeu de Sudoku. Les agents développés utilisent des actes de langage expressifs [3] et un raisonnement de type BDI (Belief, Desire, Intention) [4][5]. La communication est ici de type clavardage (chat), l'oral n'étant pas considéré dans notre travail.

Notre travail s'inscrit dans le contexte d'un projet de coopération international France-Brésil PRAIA (Pedagogical Rational and Affective Intelligent Agent) [6]. L'objectif scientifique du projet est de concevoir un ACA pédagogique ayant plus particulièrement la compétence de soutenir les activités d'un élève engagé dans des activités à l'interface d'un système informatique (par exemple un Système Tuteur Intelligent, un jeu pédagogique, ...). À partir d'hypothèses sur l'état affectif de l'élève, l'agent doit adapter sa stratégie et construire sa communication en intégrant information pédagogique et information affective.

E.3 Personnalité et Crédibilité des ECAs

La notion de crédibilité provient de travaux de recherches sur l'animation de personnages où la crédibilité signifie que l'on "ressent" que le personnage est réel [7].

Dans le but d'augmenter la crédibilité des ACA, de nombreux travaux se sont intéressés aux aspects affectifs. Les aspects affectifs (ou émotions) sont importants dans le développement des ACA parce qu'il est reconnu qu'ils modifient les expressions chez les humains: expression du visage, gestes, posture, ton et rythme de la voix, choix des mots même la respiration ou encore la température de la peau. Un sujet humain utilise naturellement ces modalités pour exprimer ses émotions.

D'après la littérature actuelle, il n'y a pas de définition formelle et largement acceptée pour le mot "crédibilité" . Cependant, les auteurs sont habituellement d'accord sur l'impact de certains aspects affectifs comme la personnalité sur la crédibilité d'un l'agent [8]. Ceci est confirmé par l'étude de Niewiadomski, Demeure et Pelachaud [9] dans laquelle les auteurs réalisent des expériences en essayant d'analyser diffèrents facteurs qui influencent la perception de la crédibilité chez des agents conversationnels Animés. D'après leurs conclusions, un agent qui utilise diffèrents canaux de communication, verbaux et non verbaux, d'une façon appropriée, a une crédibilité plus grande que celui qui utilise seulement un ou deux canaux. Une autre conclusion présentée par les auteurs montre que quelques facteurs d'individualité associés à la notion de personnalité influencent la notion de crédibilité d'un agent.

L'importance de considérer la personnalité comme un aspect qui influence la crédibilité des agents peut être résumée dans l'opinion présentée dans l'étude de Catrambone et collègues [10] dans laquelle les auteurs soutiennent que le fait de créer un agent conversationnel animé sans se préoccuper des aspects d'individualité peut résulter dans le manque de flexibilité pour les interactions de comportement, personnalité, émotion et apparence, qui sont tellement importantes. Ruttkay, Doormann et Noot [11] considèrent aussi la personnalité comme un facteur significatif, dans leur taxonomie des facteurs, pertinents pour la création des ACA.

E.4 Études Connexes

Bevacqua, Mancini et Pelachaud [12] proposent un système qui module le comportement d'un agent à travers la notion de personnalité. Les auteurs veulent créer un ACA avec des traits de personnalité reconnaissables lorsqu'ils interagissent avec des usagers en jouant un rôle plus passif dans la conversation (agents qui écoutent les sujets humains). Ils proposent un modèle basé sur quelques caractéristiques: (i) la préférence d'un agent pour l'utilisation des diffèrents canaux de communication disponibles et (ii) un ensemble des paramètres qui affectent le comportement de l'agent (réalisation de grands ou petits mouvements, par exemple). Ces caractéristiques sont établies selon les traits de personnalité de l'agent, c'est-à-dire, les auteurs proposent un système où

les traits de personnalité de l'agent sont utilisés pour déterminer les tendances de comportement d'un agent.

D'autres études sur les modèles de comportement des agents selon les traits de personnalité présentent des approches variées: approches plus génériques qui créent des modèles pour associer des émotions, comportements non verbaux et personnalités [13] ou approches plus concentrées qui isolent et associent des modalités spécifiques de communication et traits de personnalité [14]. D'autres études s'intéressent aux préférences en ce qui concerne apparence et personnalité [15].

En général, les études présentées sont centrées sur les modalités de communication non verbales et leur relation avec le comportement des agents selon des traits de personnalité. A contrario, notre étude se focalise sur la modalité verbale et sur la façon dont un agent exprime des caractéristiques de personnalité dans cette modalité.

La littérature relative au sujet de cette étude ne concerne pas seulement les agents conversationnels animés, mais aussi la génération du langage naturel. L'étude de Rowe, Ha et Lester [16], par exemple, propose un générateur de dialogues basé sur des archétypes (modèles innés présents dans la conscience collective qui sont la base du développement de la psyché humaine) pour des scénarios narratifs. De tels archétypes définissent les craintes, objectifs, motivations et caractéristiques associés é une personnalité. Selon les auteurs, les archétypes sont utilisés grâce à leur capacité de définir des ensembles de comportements qui sont familiers pour les auditeurs. La différence entre cette approche et l'étude proposée ici est qu'au lieu d'utiliser la notion des archétypes basés sur le travail de Schmidt [17], on utilise un modèle largement accepté de facettes de personnalité pour définir des buts "cachés" de communication dans nos agents.

Une étude plus semblable é celle qu'on propose ici est celle de Walker, Cahn, et Whittaker [18] où les auteurs introduisent la notion de style d'improvisation linguistique (ou, en anglais, Linguistic Style Improvisation) qui s'occupe du contenu sémantique, la forme syntaxique et la réalisation acoustique comme une stratégie pour produire des paroles. Les auteurs utilisent un ensemble de paramètres (distance sociale, image publique de l'agent et hiérarchie entre interlocuteurs) pour définir le style linguistique d'un l'agent (lequel, à son tour, collaborent avec les interlocuteurs dans la définition de la personnalité des agents avec qui ils interagissent).

Considérant l'étude citée dans [18], léétude proposée ici peu être regardée comme complémentaire, puisqu'elle pourrait être utilisée comme un paramètre pour la définition du style linguistique introduit par les auteurs. Toutefois, au lieu de focaliser dans la forme de ce qui est communiqué, cette étude se concentre sur l'intention de l'agent (buts cachés de communication) qui influencent la façon dont un agent s'exprime verbalement non seulement dans une interaction spécifique, mais dans toutes ses interactions futures.

E.5 Personnalité et Buts Cachés de Communication

Les théories qui décrivent la personnalité basées sur des traits introduisent le concept selon lequel les sujets diffèrent dans un petit nombre de dimensions qui restent stables pendant la vie et les différentes situations. Les traits de personnalité peuvent alors être définis comme des tendances à des modèles de pensées, émotions et comportements qui caractérisent des sujets humains [19].

Le modèle de personnalité à cinq facteurs (connu aussi comme le Five-Factor Model - FFM) décrit la personnalité humaine dans cinq grandes dimensions, chacune comprenant plusieurs traits psychologiques: extraversion, névrosisme, ouverture, caractère et agréabilité [20][21][22].

Chaque facteur (ou trait de personnalité) peut être subdivisé en six facettes interdépendantes selon l'Inventaire de Personnalité-Révisé NEO (NEO PI-R) [21]. Les facettes sont présentées dans la table E.1.

Les facettes aident à mieux représenter l'amplitude et la couverture de chaque facteur, en fournissant des détails qui ne sont pas perceptibles dans le trait de tempérament.

Le modèle des buts de communication cachés que nous proposons utilise les différentes facettes de personnalité pour influencer la communication des agents conversationnels Animés.

Table E.1: Facettes de la Personnalité (NEO PI-R)

Extroversion	Nérvosisme	Ouverture	Caractère	Agréabilité
Accueil	Anxiété	Fantaisie	Compétence	Confiance
Grégarisme	Hostilité	Esthétique	Ordre	Moralité
Assurance	Dépression	Sentiments	Sens du Devoir	Altruisme
Activité	Auto-conscience	Aventure	Direction	Coopération
Recherche de Sensations	Impulsivité	Idées	Autodiscipline	Modestie
Emotions Positives	Vulnérabilité	Valeurs	Délibération	Sensibilité

Table E.2: Facettes de Personnalité et Comportements Associés

Personnalité	Facette	Description
Extraversion	Accueil	Décrits comme véritablement intéressés dans d'autres personnes et avec une tendence à nourir des sentiments positifs à l'égard des autres. Tendent à établir des relations proches et intimes (amitié) très vite.
Nérvosisme	Auto-conscience	Décrits comme sensibles aux opinions des autres personnes et aussi à la critique. Tendence à se sentir toujours jugés.
Ouverture	Sentiments	Décrits comme conscients de ses émotions. Tendent à exprimer leurs émotions ouvertement.
Caractère	Compétence	Décrits comme disponibles pour aider les autres. Trouvent cela réconfortant et compensateur.
Agréabilité	Altruisme	Décrits comme des sujets qui se jugent capables d'exécuter une certaine tâche. Ils croient en leur intelligence et contrôle.

Malgré l'existence de 30 facettes passibles d'exploration, seules les facettes présentées dans la table E.2 ont été choisies.

Pour la conception du modèle, les facettes choisies ont été associées au modèle cognitif des émotions OCC (OCC sont les lettres initiales des auteurs: Ortony, Clore et Collins)[23]. Le modèle OCC formalise que les émotions résultent de l'évaluation de trois aspects du monde: les évènements (façon dont les gens perçoivent les évènements), les agents (peuvent être des gens, des animaux ou des abstractions) et les objets (objets inanimés). Les perceptions émotionnelles sont valorisées à partir de leurs objectifs (elles sont promues ou empêchent que les objectifs et préférences d'un autre soient atteints), modèles et préférences.

Selon le modèle OCC, les émotions comme la peur (valence négative) et l'espoir (valence positive) sont déclenchées lorsqu'une personne se concentre sur l'importance d'un évènement. Une personne éprouve de l'espoir si quelque chose de souhaitable (évènement favorable) arrive et éprouve de la peur si quelque chose de mauvais (évènement défavorable) arrive.

Basé sur les émotions de peur et d'espoir, les évènements souhaitables selon chaque facette de la personnalité (présentée dans la table 2) ont été définis. Les facettes de personnalité ont été isolées, c'est-à-dire, chaque facette a été considérée séparément, et pas sous l'influence des autres traits de personnalité et des autres facettes.

De la même façon, des buts de communication "cachés" ont été définis. Les buts proposés dans cette étude existent d'une façon inconsciente (c'est pour cela qu'ils sont nommés cachés)

et ils interfèrent dans toutes les interactions de l'agent, indépendamment de la tâche qui sera exécutée. Ainsi, un agent extraverti ayant la facette accueil, a envie d'établir un relation d'amitié (espoir) et, pour y arriver, il devra interagir avec l'usager de façon à créer une certaine intimité. Il posera des questions, indiquant qu'il s'intéresse à l'usager, et aura une attitude positive à l'égard de celui-ci. La figure E.1 montre les autres but cachés que nous avons définis.

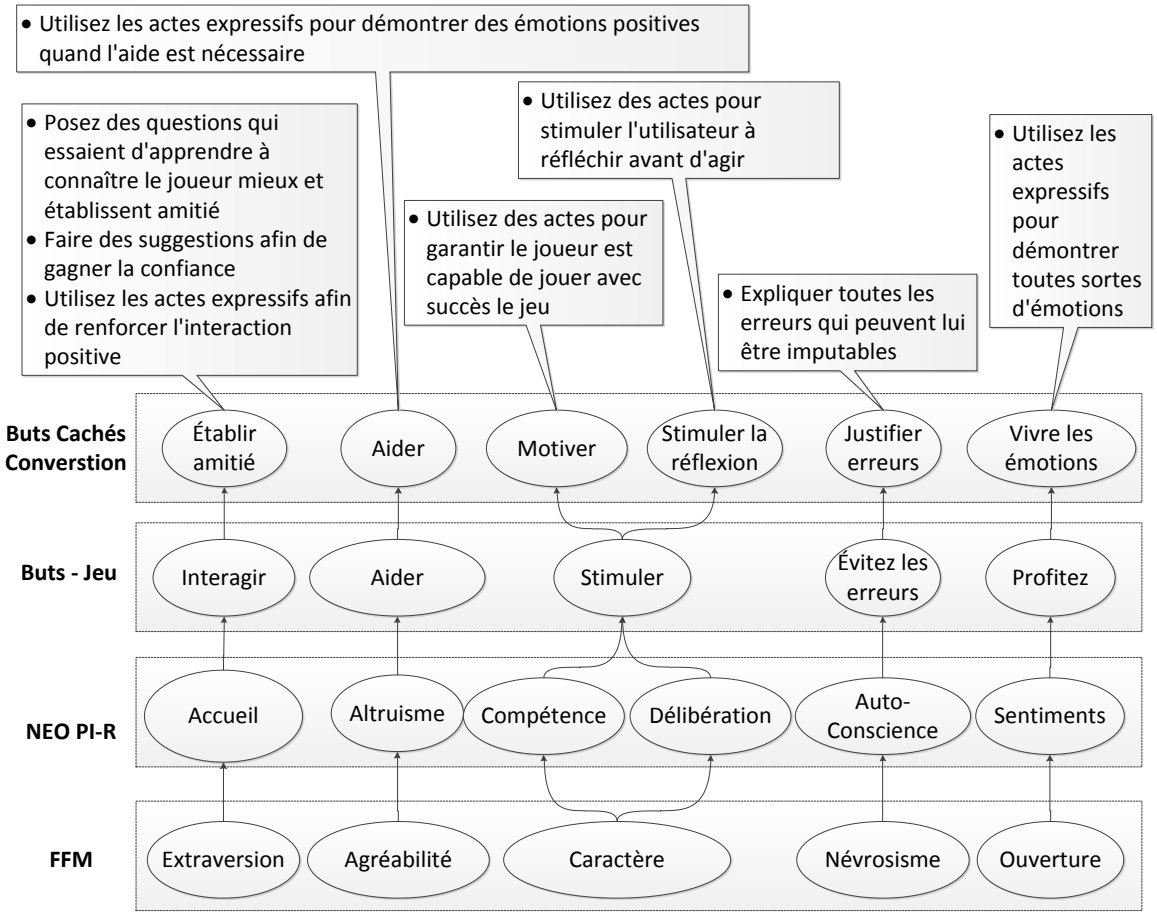

Figure E.1: Modèle d'Objectifs Cachés de Conversation

Un agent ayant une personnalité agréable avec une facette altruiste souhaitera aider son interlocuteur indépendamment de la tâche exécutée (on peut penser aussi au cas d'un interlocuteur qui raconte ses problèmes). Un agent ayant une personnalité consciencieux avec une facette de compétence aura envie de stimuler l'usager à atteindre ses objectifs. En réalité, la facette de compétence a été associée avec la facette de délibération. l'agent compétent a l'espoir d'atteindre ses objectifs (et il se croit compétent), alors il stimulera son interlocuteur à agir de la même façon, puisque jouer est une activité qui demande la participation d'un autre.

Un agent névrosé avec une facette d'auto-conscience aura peur d'être jugé, et, par conséquent, il essaiera d'expliquer toutes les erreurs qui peuvent lui être imputables. Enfin, un agent ouvert et avec une facette de sentiments essaiera tout simplement de profiter de la situation, dans l'attente de vivre intensément ses sentiments.

Les buts, bien qu'ayant été définis en fonction d'une application de jeu particulier pour des besoins vérifications du modèle, s'ajustent à diverses situations. Donc, un agent qui a la facette d'accueil dans une personnalité extravertie essaiera (inconsciemment), dans ses interactions quotidiennes, à établir une amitié avec son interlocuteur. De la même façon, un agent névrosé avec la facette d'auto-conscience évitera les jugements des autres (prenant soin de ne faire rien qui puisse

Table E.3: Actes de Conversation - Langage de Conversation Expressif

Assertifs	Commissifs	Directeurs	Déclaratifs	Expressifs
Affirmer	S'engegaer à	Demander	Déclarer	Remercier
Nier	Promettre	Poser des questions	Approuver	S'excuser
Penser	Garantir	Suggérer	Se rétracter	Complimenter
Dire	Accepter	Conseiller	Annuler	Féliciter
Rappeler	Refuser	Exiger		Se plaindre
Informer	Renoncer	Ordonner		Protester
Contredire	Offrir	Interdire		Saluer

être incompris).

E.6 Application et Expérimentation

Notre modèle des buts de communication cachés a été appliqué dans des agents développés en utilisant une approche de croyances, désirs et intentions (belief, desire, intentions - BDI) [4][5]. Le modèle BDI a été associé à un langage de conversation expressif proposé en [3] qui formalise 33 actes de conversation (présentés dans la table E.3) avec ses conditions de succés et satisfaction.

Les agents développés agissent dans une application de jeu, celui du Sudoku. L'application a été développée de telle façon à ce que l'agent joue le rôle de compagnon de l'usager, en dialoguant et réagissant au fur et à mesure que le jeu avance (selon la personnalité, l'agent pourra ou non commenter les faux mouvements, exprimer joie ou tristesse, etc.).

Les agents ont été modélisés pour réaliser trois différentes tâches. La première tâche (présentation) a pour but de présenter l'environnement du jeu et expliquer les règles. La deuxième tâche (observation) comprend l'observation des mouvements de l'usager. La troisième et dernière tâche (clôture) comprend une interaction finale avec l'usager, avec des commentaires sur la partie de jeu qui vient de se dérouler.

L'influence du modèle des buts cachés dans chacune des tâches varie beaucoup. La tâche de présentation, par exemple, peut inclure plus ou moins détails, selon la personnalité de l'agent (dans le cas d'un agent altruiste). La tâche d'observation peut comprendre ou non l'intrusion de l'agent dans les mouvements faux ou corrects de l'usager. La tâche de clôture est celle où l'émotion d'espoir ou peur sera ou non confirmée. Donc, l'agent utilise plusieurs actes expressifs pour manifester son émotion courante.

Aussi, le comportement général de l'agent sera présent dans toutes les tâches, comme un comportement verbal ordinaire. Un agent accueillant (extraverti) posera des questions sur les préférences de l'usager ("Vous aimez le jeu?") pour essayer d'établir une relation d'amitié (ces questions seront posées pendant le jeu). Un agent névrosé se plaindra constamment et exprimera sa peur d'être jugé (en disant, par exemple, "Ce n'est pas notre faute si ce jeu est tellement difficile!" ou "Si quelqu'un arrive, il suffit de cliquer sur le bouton -Clear- et personne ne saura combien des mouvements faux on a fait..."). Un autre exemple est celui d'un agent compétent qui stimulera l'usager à ne pas quitter le jeu et à réfléchir avant de faire un nouveau mouvement (dans le cas d'un mouvement faux, par exemple).

Le comportement non verbal est aussi implémenté. Les agents développés utilisent le toolkit DIVA (http://www.limsi.fr/ jps/online/diva/divahome/) pour la définition de l'apparence du personnage et de son comportement non verbal approprié (le comportement non verbal a été conçu selon des études préalables, présentés précédemment). La figure 2 montre l'interface du jeu développé et l'agent conversationnel animé. Il faut noter que, malgré les actes de parole for-

malisés par le langage de conversation expressif mentionnés ici, l'agent entier a été conçu pour parler en anglais. Donc, la figure 2 présente le log d'une conversation en anglais qui est en cours (cété droite supérieur).

En somme, les buts de communication cachés proposés dans notre modèle, et la formalisation des actes de parole proposés dans le langage de communication expressif combiné avec une logique basée sur des croyances, désirs et intentions, fournissent le mécanisme de raisonnement des intentions communicatives de l'agent. En raison des limites du champ de recherche de traitement de langage naturel et aussi de l'objet de l'étude, les phrases dites par l'agent ont été préétablies selon les intentions communicatives possibles et les actes de parole disponibles. De la même façon, les phrases qui pourraient étre dites par l'usager ont été préétablies et étaient disponibles dans une boîte de sélection (selon la figure E.2 - côté droit inférieur).

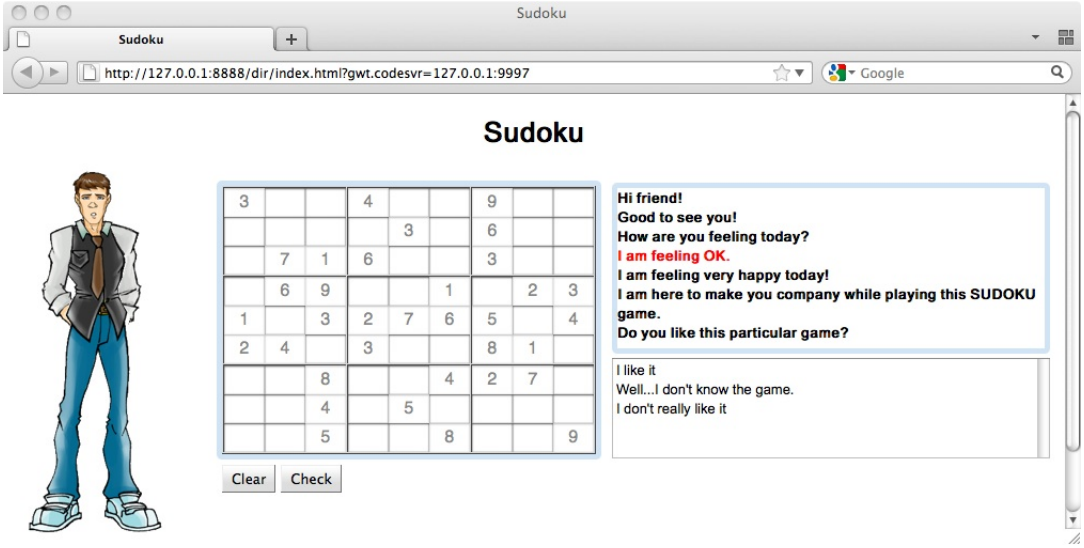

Figure E.2: Scénario d'Application et Agent

E.7 Évaluation du modèle

Une évaluation a été réalisée pour mesurer si les usagers qui interagissent avec les agents étaient capables de reconnaître/identifier des aspects de la personnalité des agents (H1) et s'ils étaient capables d'identifier les buts de communication cachés à travers le comportement de l'agent, identifiant ses craintes et ses espoirs (H2). Finalement, une dernière hypothèse concerne la vérification de la crédibilité des agents (H3).

E.7.1 Participants et Protocole

La sélection des participants pour la vérification du modèle (interaction avec des agents développés) a pris en compte leur maîtrise de l'anglais (des vérifications préalables ont été faites) et leurs connaissances préalables des Agents Conversationnels Animés. 12 participants ont été choisis, et 75% d'entre eux (9 participants) parlaient anglais couramment et les autres 25% parlaient un anglais de niveau avancé (les participants comprenaient des natifs Brésiliens et des Américains). En ce qui concerne les connaissances préalables des ACA, 58,3% (7 participants) ont rapporté avoir des connaissances préalables sur le thème, tandis que 41,6% (5 participants) néavaient aucune connaissance préalable des ACA. Dans notre étude, on a considéré qu'une connaissance préalable est toute sorte d'interaction avec ce type d'agent avant l'expérience de cette étude (par exemple, d'autres applications ou des sites web intégrant des agents conversationnels

animés).

Le protocole d'évaluation a commencé avec une interview individuelle (conduite par un professeur d'anglais) avec tous les participants volontaires pour la vérification de leur niveau de connaissance de l'anglais. La vérification réalisée dans cette première rencontre a entraîné l'exclusion de plusieurs participants (au début on avait 20 volontaires), puisque la connaissance de l'anglais était essentielle pour la compréhension de la conversation. Ensuite, les participants ont été interviewés une seconde fois pour l'évaluation des connaissances préalables sur ACA.

La phase suivante a été celle de l'explication de l'expérimentation et d'une introduction générique sur les agents conversationnels animés. Les participants qui n'avaient pas de connaissances préalables sur les ACA ont eu le temps d'interagir avec des autres agents disponibles (dans des pages web). Il faut souligner que l'objectif de cette phase a été de mettre tous les participants au même niveau, et donc, ils n'ont pas été accompagnés ou guidés dans cette interaction.

Dans la phase finale, les participants ont interagi avec toutes les facettes de personnalité modelées (sessions du jeu). Pour cela, chaque participant a joué le jeu de 5 é 10 fois avec des différents agents (plusieurs facettes de personnalité ont interagi individuellement dans un jeu). Cinq d'entre eux étaient obligatoires (parce qu'il s'agissait de cinq différentes facettes modelées) et les autres cinq jeux étaient optionnels (les usagers pouvaient jouer plus d'une fois avec les agents de leur préférence).

À la fin de chaque partie de jeu, les participants ont rempli un questionnaire immédiatement (nommé agent evaluation questionnaire - AEQ). À la fin de tous les jeux, les participants ont rempli un questionnaire comparatif (overall questionnaire - OQ). Les questionnaires ont été évalués avec les fichiers des données de conversation collectées (usage data log). Les données de conversation ont rendu possible accompagner les attitudes de chaque agent en chaque conversation spécifique, aussi que les attitudes des usagers pendant la conversation.

Le questionnaire AEQ contenait des questions posées pour vérifier l'hypothèse H1 (si les usagers seraient capables de reconnaître/identifier des aspects de la personnalité des agents) et H2 (identification des buts cachés de communication à travers le comportement de l'agent). Quelques questions posées dans le questionnaire avaient aussi le but de vérifier la crédibilité de l'agent (hypothèse H3). L'annexe B présente liste les questions du questionnaire AEQ.

La crédibilité de l'agent a été évaluée selon les critères suivants: (i) les participants se rendaient compte que l'agent exprimait des émotions et des comportements selon la personnalité; (ii) l'agent générait un comportement émotionnel dans les participants.

Le questionnaire OQ (annexe C) a été appliqué seulement pour confirmer/éclaircir des possibles doutes qui n'ont pas été résolues dans le questionnaire AEQ et pour obtenir une vision globale comparative entre toutes les facettes de personnalité. Le questionnaire OQ présente des comportements décrits précédemment (à peu près comme la question 8 du questionnaire AEQ) qui devraient être attribués à chacun des agents avec qui l'usager ira interagir (le comportement pourrait être identifié ou non pendant la conversation).

E.7.2 Conclusions des évaluations

Les évaluations ont démontré que les usagers sont capables de reconnaître quelques facettes de la personnalité des agents avec qui ils ont interagi (H1). Les facettes choisies pour les traits d'extraversion et névrosisme ont été facilement reconnues. La reconnaissance des facettes choisies pour les traits d'agréabilité et caractère a été moins significative. En ce qui concerne les résultats du questionnaire OQ, la facette choisie pour le trait d'ouverture aux expériences fut la seule qui n'a pas été facilement reconnue dans la comparaison avec d'autres agents.

L'évaluation des questionnaires a démontré que la facette des sentiments (trait ouverture aux expériences) n'est pas facilement reconnaissable parce que les sentiments négatifs apparents dans la facette choisie pour la personnalité névrosisme ont été plus évidents et transparents que les sentiments démontrés par l'agent ouvert avec une facette sentimentale. La même conclusion a été obtenue pour l'hypothèse H2 (identification des objectifs cachés de communication à travers le

comportement de l'agent).

On croit que l'explication pour ce résultat est la suivante: l'objectif caché de l'agent ouvert (facette sentiments) est très générale et pas évidente dans le scénario de l'expérience. Le scénario du jeu Sudoku comprenait des questions de type vrai-faux (mouvement correct ou faux), ce qui a résulté dans la prévalence de l'objectif caché d'aider ou justifier les faux mouvements, dans la démonstration des sentiments équivalents. Un agent ouvert montre ses émotions d'une façon plus générique et moins associée à des évènements évidents, et, portant, moins perceptibles à long terme. En ce qui concerne la crédibilité (H3) les résultats montrent que les participants ont reconnu le côté émotionnel et de personnalité de la plupart des agents (é l'exception de l'agent ouvert aux expériences) e que les personnalités/émotions reconnues étaient conformes avec l'agent avec qui ils interagissaient. Aussi, les participants ont décrit des différentes émotions générées par l'interaction avec les agents (joie, irritation, confusion, pitié ...). Les deux conclusions indiquent que les participants attribuent un certain degré de crédibilité aux agents.

E.8 Considérations Finales

Cette étude a proposé un modèle des objectifs cachés de communication basés sur des facettes de traits de personnalité pour augmenter la crédibilité des Agents Conversationnels Animés. Le modèle proposé a été vérifié dans un scénario d'application du jeu Sudoku à travers des différents agents doués de différentes facettes de personnalité qui interagissent avec les usagers, pour leur tenir compagnie pendant le jeu. L'association de formalisation logique de 33 différents actes de parole (langage de conversation expressif) avec une approche basée sur des croyances, désirs a rendu possible le développement le contrôle du dialogue de chaque agent, selon le modèle des objectifs cachés proposé. Donc, le modèle permet une communication plus affective entre l'usager et l'agent, puisque l'agent est influencé par ces objectifs dans toutes ses interactions.

En ce qui concerne la taxonomie utilisée pour guider le développement de cette étude (présentée dans l'introduction), la contribution fournie par l'étude consiste à proposer un modèle différencié pour augmenter "l'illusion de la vie" pour ceux qui interagissent avec de tels agents dans des différentes applications. L'étude proposée essaie d'investiguer de quelle façon l'aspect affectif de la personnalité peut influencer des dialogues entre agents et des sujets humains.

Une prochaine phase de l'étude présentée ici comprendra la définition des objectifs cachés de communication pour toutes les facettes de personnalité, et aussi une étude sur la combinaison des facettes e son implication sur le comportement des agents. Donc, le modèle pourrait être élargi et incorporé dans d'autres domaines d'application pour augmenter la crédibilité de cette catégorie d'agents.

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