An Empathic Virtual Dialog Agent to Improve Human-Machine Interaction

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ABSTRACT

Recent research has shown that virtual agents expressing empathic emotions toward users have the potentiality to enhance human-machine interaction. To identify under which circumstances a virtual agent should express empathic emotions, we have analyzed real human-machine dialog situations that have led users to express emotion. The results of this empirical study have been combined with theoretical descriptions of emotions to construct a model of empathic emotions. Based on this model, a module of emotions has been implemented as a plug-in for JSA agents. It determines the empathic emotions (their types and intensity) of such agents in real time. It has been used to develop a demonstrator where users can interact with an empathic dialog agent to obtain information on their emails. An evaluation of this agent has enabled us to both validate the proposed model of empathic emotions and highlight the positive user's perception of the virtual agent.

1. INTRODUCTION

A growing interest in using virtual agents as interfaces to computational systems has been observed in recent years. This is motivated by an attempt to enhance human-machine interaction. Humanoid-like agents are generally used to embody some roles typically performed by humans, as for example a tutor [13]. The expression of emotions can increase their believability by creating an *illusion of life* [3]. Recent research has shown that virtual agent's expressions of empathic emotions enhance users' satisfaction [14, 26], engagement [14], performance in task achievement [22], and the perception of the virtual agent [5, 23].

In our research, we are particularly interested in the use of virtual dialog agents in information systems. Users interact using natural language to find out information on a specific domain. We aim to give such agents the capability to express empathic emotions toward users while dialoging. Our aim is to improve interaction using empathic agents [14, 26, 5, 23, 22].

Empathy is commonly defined as the capacity to "put your-self in someone else's shoes to understand her emotions" [20]. To be empathic assumes one is able to evaluate the emotional dimension of a situation for another person. To achieve this goal, a virtual agent should know in which circumstances which emotions may be felt. To endow a virtual dialog agent with empathic capabilities, one way is to provide it with a representation of the conditions of users' emotions elicitation during dialog. Then, the agent can deduce the emotions potentially felt by the user during the interaction.

Several computational models of emotions include a representation of emotions elicitation conditions (as for instance in [7, 28]). It enables one to determine which emotions of the virtual agent are triggered during an interaction. Generally, researchers [7, 28, 10] use a specific cognitive psychological theory of emotion (mainly the OCC model [19]) to define the agent's emotions. In this approach, the authors assume that the emotions that may appear during interaction with one or multi agents and their conditions of elicitation correspond to those described in the chosen theory. For an empathic virtual dialog agent, the emotions that should be modeled are those that may be felt by the user during the dialog.

Our computational model of empathic emotions is based on an empirical and theoretical approach. An exploratory analysis of real human-machine dialogs that have led users to express emotions have been done to try to identify the characteristics of emotional dialogic situations. Combined with the descriptions of emotions in cognitive psychological theories, the types and the conditions of elicitation of emotions that may be triggered during human-machine dialogs have been defined. Our model of empathic emotions have been implemented as a plug-in for JSA agents (*Jade Semantics Agents* [15]). The JSA agent technology has been used to develop an empathic dialog agent. A subjective evaluation of this agent has been performed. It enabled us both to validate the model of empathic emotions and to highlight the positive impact of empathic virtual agent on human-machine interaction.

The paper structure is as follow. After giving an overview of existing empathic virtual agent models (Section 2), we present our model of empathic emotions (Section 3). Section 4 describes the implementation of empathic dialog virtual agent followed by its evaluation (Section 6).

2. EXISTING EMPATHIC VIRTUAL AGENTS

Empathy in human-machine interaction can be considered in two ways: a user can feel empathic emotions toward a virtual agent (for instance in *FearNot!* [21]) or a virtual agent can express empathic emotions toward a user [7, 16, 28, 25]. In our research, we focus on the empathy of a virtual

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agent toward users.

Most of empathic virtual agents are based on the OCC model [19]. Consequently, only two types of empathic emotions are considered : *happy-for* and *sorry-for*. However, research in psychology suggests that the type of an empathic emotion toward a person is similar to the type of the emotion of the latter [11]. Indeed, by empathy, someone may, for instance, feel fear for another person. Therefore, there exist as many types of empathic emotion as types of non empathic one. Then, an empathic virtual agent should *feel* an empathic emotion of frustration for the user if it thinks the user is frustrated.

In [7], the *happy-for* (respectively *sorry-for*) emotion is elicited by the empathic agent when a goal of another agent (virtual agent or user) is achieved (respectively failed). The empathic virtual agent has a representation of the other agent's goals. It deduces these goals from their emotional reactions. Consequently, the agent knows the other's goals only if they have been involved in an emotion elicitation. Therefore, the other agent's goals representation might be incomplete. In [28], the virtual agent expresses *happy-for* (respectively *sorry-for*) emotion only if it detects a positive (respectively negative) emotional expression of its interlocutor. The agent's empathic emotions are in this case elicited by the perception of the expression of an emotion of another agent. Indentically, in [25], the virtual agent expresses empathy according to the user's emotions (frustration, calm or joy) recognized through physiological sensors. However, an empathic emotion can be elicited even if this emotion is not felt or expressed by the interlocutor [24].

Another approach consists in observing real interpersonal mediated interactions in order to identify the circumstances under which an individual expresses empathy and how it is displayed. The system *CARE* (*Companion Assisted Reactive Empathizer*) has been constructed to analyze user's empathic behavior during a treasure hunt game in a virtual world [16]. The results of this study are domain-dependent. The conditions of empathic emotion elicitation in the context of a game may not be transposable in another context (as for example the context in which a user interacts with a virtual agent to find out information on a specific domain).

Our method to create empathic virtual agent is based both on a theoretical and empirical approaches. It consists to identify through psychological cognitive theories of emotion and through the study of real human-machine emotional dialogs, the situations that may elicit users' emotions. In the next section, we present our model of empathic emotions.

3. A MODEL OF EMPATHIC EMOTIONS

An empathic virtual dialog agent should express empathic emotions in situations in which the user potentially felt an emotion. The agent should therefore know the conditions of elicitation, the types and intensity of the users' emotions during the dialog.

3.1 Theoretical Foundations.

According to the *cognitive appraisal theories* [31], emotions are triggered by a subjective interpretation of an event. This interpretation corresponds to the evaluation of a set of variables (called *appraisal variables*). When an event occurred (or is anticipated) in the environment, the individual evaluates the latter through a set of variables. The values of these variables determine the type and the intensity of the elicited emotion. In our work, we focus on the goal-based emotions [19]. We consider the following appraisal variables (extracted from [30]):

- *The consequence of the event on the individual goal*: an event may trigger an emotion only if the person thinks that it affects one of her goals. The consequences of the event on the individual goal determine the elicited emotion. For instance, fear is triggered when a survival goal is threatened or risks to be threatened. Generally, failed or threatened goals elicit negative emotions whereas achieved goals trigger positive ones.

- *The causes of the event*: the causes of an event that lead to emotion elicitation may influence the type of the elicited emotion. For instance, a goal failure caused by another agent may trigger anger.

- *The consistency of consequences with the expectations*: the elicited emotion depends on the consistency between the current situation (*i.e.* the consequences of the occurred event on the individual's goals) and the situation expected by the individual.

- *The potential to cope with consequences*: the coping potential represents the capacity of an individual to deal with a situation that has led to a threat or failed goal. It may influence the elicited emotion.

The interpretation of an event (*i.e.* the evaluation of appraisal variables and then the elicited emotion) depends principally on the individual's goals and beliefs (on the event, its causes, its real and expected consequences, and on her coping potential). That explains the different emotional reactions of distinct individuals in front of a same situation.

In a dialog context, an event corresponds to a communicative act. Consequently, according to the appraisal theory of emotion [31], a communicative act may trigger a user's emotion if it affects one of her goals. To identify more precisely the dialogical situations that may lead a user to feel emotion, we have analyzed real human-machine dialogs that have led a user to express emotions. We present in the next section the results of this study.

3.2 The Analysis of Users' Emotions Elicitation in Human-Machine Interaction.

The analyzed dialogs have been derived from two vocal applications. The users interact orally with a virtual dialog agent to find out information on a specific domain (on stock exchange or on restaurants in Paris). First, the dialogs have been annotated with the label *negative_emotion* by two annotators[1]. The annotations have been done based on vocal and semantic cues of user's emotions. Secondly, these dialogs have been annotated with a particular coding scheme in order to highlight the characteristics of the dialogical situations that may elicit emotions in a human-machine context (for more details on the coding scheme see [18]). The analysis of the annotated dialogs has enabled us to identify more precisely the characteristics of a situation that may lead to a *negative* emotion elicitation in human-machine interaction. Concerning the appraisal variable *consequence of the event*,

[1]Unfortunately, the dialog corpus did not cover situations that have led users to express positive emotion

a communicative act may trigger a user's negative emotion when it involves the *failure of a user's intention*[2]. The *cause of the event* that seems to elicit a user's negative emotion is in some cases the dialog agent because of a *belief conflict on an intention* (the agent thinks the user has an intention different from her own one). In the negative emotional situations, the *user's expectations* seem to be inconsistent with the situation that she observes. After the failure of her intention, the user tries sometimes to achieve it in another way (*coping potential*). In some cases, the user seems not to be able to cope with the situation.

The results of this study on human-machine emotional dialogs are not sufficient to construct a model of empathic emotions. Consequently, these results have been combined with the descriptions of emotions from appraisal theory in order to deduce the type and the intensity of the emotions that a user may experience during human-machine dialogs.

3.3 The Virtual Agent's Empathic Emotions

To identify the types of emotions a user may feel during human-machine interaction, we have explored the work of Scherer[30] and have tried to correlate his descriptions of the conditions of elicitation of emotion type to the characteristics of emotional dialogical situations introduced above. We have chosen the Scherer's approach because his model is constructed on an analysis of the consensual appraisal variables coming from different theories. In the OCC model, only few appraisal variables are considered. For instance, the coping potential is not taken into account.

A positive emotion is generally triggered when a goal is completed. More precisely, if the goal achievement was expected, an emotion of **satisfaction** is elicited; while, if it was not expected, an emotion of joy appears [30]. In the human-machine dialogs, a user's goal achievement corresponds to the successful completion of her intention. Generally, the user expects that her intentions (underlying her communicative act) will be achieved. Therefore, we consider only the emotion of satisfaction. We suppose that the user may experience satisfaction when one of her intentions is completed.

A goal failure generally triggers a negative emotion. If a situation does not match with an individual's expectations, an emotion of **frustration** is elicited [30]. Consequently, the user may experience frustration when one of her intentions failed. An emotion of **sadness** appears when the individual cannot cope with the situation. On the other hand, if she can cope with the situation, an emotion of **irritation** is elicited [30]. The user may feel sadness when she does not know any other action that enables her to carry out her failed intention. If an action can be achieved by the user to complete her intention, she may experience irritation. When the goal failure is caused by another person, an emotion of **anger** may be elicited. In the dialogs analysis described above, this situation may correspond to a user's intention failure caused by the dialog agent due to a belief conflict. The user may experience anger toward the agent when a belief conflict with the dialog agent has led to a goal failure.

Based on research on emotion's intensity [19, 9, 7, 28], we suppose that the intensity of the elicited emotion is positively correlated to the *unexpectedness* of the situation, to the effort invested by the user to try to carry out her intention, to the *importance for the user to achieve her intention* (in the case of positive elicited emotion), to *the importance not to have her intention failed* (in the case of negative elicited emotion) and negatively correlated to the user's *coping potential*.

Of course, we cannot deduce the exact emotion felt by the user from this description of emotions. Other elements (as for example the mood, the personality, and the current emotions) influence the elicitation of an emotion. However, this approach enables us to provide the virtual agent with information on the dialogical situations that *may* trigger a user's emotion. Indeed, from these rules on emotions elicitation, the virtual agent can deduce the emotion potentially felt by the user during the dialog. This information is used to elicit her empathic emotions. When the virtual dialog agent thinks the user has potentially an emotion, an empathic emotion may be triggered toward the latter. For instance, if the agent thinks the user feels frustration in the current situation, the agent triggers an empathic emotion of frustration toward the user. The elicitation of empathic emotions and their intensity depends on different factors as for example the relation between the user and the agent. To illustrate it, we introduce a *degree of empathy*. It is positively correlated to the similarity and the relationship between the user and the virtual dialog agent. Indeed, as highlighted in [21], people experience more empathic emotions with persons with whom they have some similarities (for example the same age) or a particular relationship (as friendship). The degree of empathy depends also on the degree to which the user deserves or not deserves the situation. Generally, people tend to be more pleased (respectively displeased) for others if they think the situation is deserved (respectively not deserved) [19].

The conditions of empathic emotions elicitation have been formalized in terms of mental attitudes. They are represented by particular mental states, *i.e.* combinations of beliefs, uncertainties, and intentions. This formalization enables a BDI-like agent [27, 29], which reasons and acts according to its mental state, to infer its empathic emotions during the interaction (for more details on the formalization see [17]).

4. IMPLEMENTATION OF THE MODEL OF EMPATHIC EMOTIONS

Based on the model of empathic emotions described above, a *module of emotions* has been developed. It corresponds to a plug-in for the JSA agents (*Jade Semantics Agents*). These agents are implemented within the JSA framework [15], a plug-in of the JADE platform (*Java Agent DEvelopment Framework*). The JSA framework[3] enables one to implement BDI-like dialog agent. The module of emotions we have implemented provides empathic capabilities to these agents. It identifies dynamically the empathic emotions (type and intensity) of the JSA agent toward its interlocutor.

4.1 A Module of Emotions

The JSA agents are able to interpret the meaning of a received message and to respond to it automatically. The process for the interpretation and the reasoning are implemented trough rules called SIP (Semantic Interpretation

[2]In the human-machine dialogs we studied, we have observed the user's and agent's intentions with more particular attention. An intention is defined as a persistent goal (for more details see [29])

[3]The JSA framework is open-source [12]

Principle)[15]. The module of emotions is composed of a set of java classes to represent emotions, two SIPs for the emotions elicitation, specific methods to compute and update the intensity of emotions, and a graphic interface to visualize the agent's emotions and their intensity dynamic (Figure 1).

Based on the speech act theory [1], the JSA agents use a model of communicative acts [29] to infer the user's beliefs and intentions concerning the dialog. For instance, when the user asks an information, the dialog agent deduces that the user has the intention to know the information and has the intention that the agent knows her intention to know the information. The agent infers also that the user believes that her intentions will be achieved following the enunciation of the communicative act. From these user's mental attitudes and given the rules on empathic emotions elicitation, the agent computes its empathic emotions toward the user. For instance, if the agent believes that one of the user's intentions has just failed, it infers that the user potentially feels an emotion of frustration. Then, an empathic emotion of frustration is triggered. If it thinks that no other action enables the user to achieve this intention, an empathic emotion of sadness is elicited. The intensity of emotion is computed according to the values of the intensity variables introduced in the previous section. The intensity decreases when no emotion is elicited. The updating of the intensity when an emotion is triggered is inspired with the dynamic model of emotion proposed in [32].

4.2 EDAMS : An Empathic Dialog Agent in a Mail System

From the JSA framework and the module of emotions introduced above, a demonstrator of an empathic dialog agent (called *EDAMS* : An Empathic Dialog Agent in a Mail System) has been implemented. The user interacts with the EDAMS to obtain information on her mails. She selects predefined sentences on the interface to dialog with the agent (Figure 2).

In order to display the empathic emotions, a 3D talking head is used (Figure 2). During the dialog, the module of emotions transfers to the talking head the type and intensity of the empathic emotion to display. The talking head adopts the facial expression[4] corresponding to this emotion (Figure 3). To give the capability to the EDAMS to answer to the user's requests, different information on the user's messages (type of the message, sender, level of urgency, content, etc) are added to the EDAMS' database. A module has been developed to traduce the user's request in natural language to FIPA-ACL [8], the language used by the JSA agents to reason. Some values have to be fixed by the programmer to enable the EDAMS to compute the intensity of emotions: the degree of certainty of the user to achieve her intentions, the importance for the user that her intention is achieved and not failed, and the agent's degree of empathy. These values may depend on the application context, the type of the intentions and on the user's characteristics.

Let us illustrate our system through some examples of emotional interactions between a user and the EDAMS: when the EDAMS is started, if the user asks the system to close her mailbox (by selecting the sentence "Je voudrais fermer ma messagerie" (I would like to close my mail box), Figure 2), an empathic emotion of frustration is expressed because the user's intention cannot be achieved (the mailbox should first be opened). If the user asks the EDAMS to connect her with another person (by selecting, for instance, the sentence "Peux-tu me mettre en contact avec Bobby ?" (Can you put me in contact with Bobby, Figure 2), the EDAMS expresses an empathic emotion of sadness because it cannot satisfy the user's request and thinks that no other action enables the user to complete this intention. If the user asks the EDAMS to tell her the new messages (by selecting the sentence "Pourrais-tu me lire mes nouveaux messages ?" (Could read me my new emails?), the talking head expresses an emotion of satisfaction and reads the user's new messages. When the user selects the sentence "No, it is not what I want", the agent supposes that a belief conflict on the user's intention has just occurred and displays an emotion of anger to express the fact that it is angry against itself (because it supposes that the user is angry against it)[5].

The EDAMS has been used to evaluate the impact of an empathic virtual agent on the human-machine interaction, and more precisely on the user's perception of the agent. In the next section, we present the experimental protocol and the results of the evaluation.

5. THE IMPACT OF AN EMPATHIC VIRTUAL AGENT ON USER'S PERCEPTION

Recent research has shown that virtual agents which express empathic emotions toward a user enhance human-machine interaction [5, 14, 22, 23, 26]. However, these few experimentations of emotional agents are mostly in the context of game [5, 14, 22, 26]. Moreover, the results seem to depend on the culture of the subjects [4, 5]. They are sometimes contradictory [2, 22]. As highlighted by Becker *et al.* [4], the agent's expressions of emotions may be harmful to the interaction when they are incongruous to the situation. Today, no research seems to have explored, in a French cultural context, the impact on the interaction of an empathic dialog agent used as information system. Therefore, an evaluation of the EDAMS has to be done to assure the effect of the agent's expressions of empathic emotions on the interaction.

The evaluation of the EDAMS has been performed in order to test the following hypotheses:

1. when a user interacts with a virtual agent to find out information in a particular domain, she perceives *more positively* the agent when the latter expresses empathic emotions;

2. when a user interacts with a virtual agent to find out information in a particular domain, she perceives *more negatively* the agent when the latter expresses incongruous emotions to the dialog situations.

5.1 Design of the Experiment

In order to test our hypotheses, three versions of the EDAMS have been developed:

[4]Few research has been done on the expressions of empathy [6]. In our work, we suppose that the facial expression corresponding to an empathic emotion is similar to the one of an emotion of the same type

[5]The most appropriate emotion to express when the agent thinks the user is angry against it, is unclear. Another possibility can be considered, as for example the expression of sadness as the agent is sorry it could not help appropriately the user

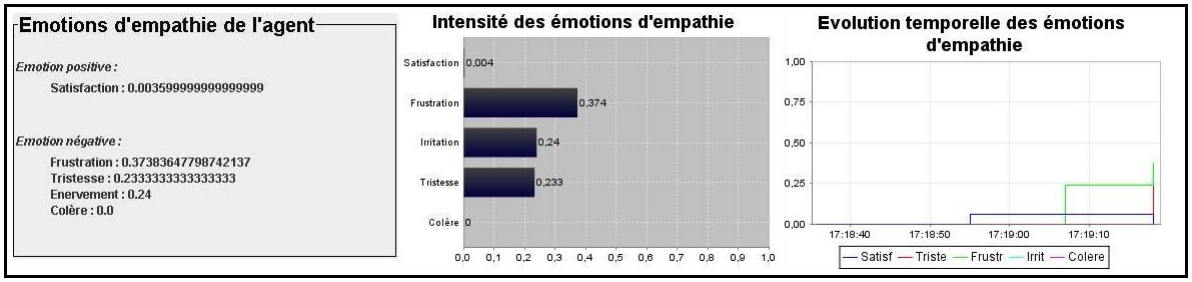

Figure 1: Screenshot of the graphic interface of the module of emotions

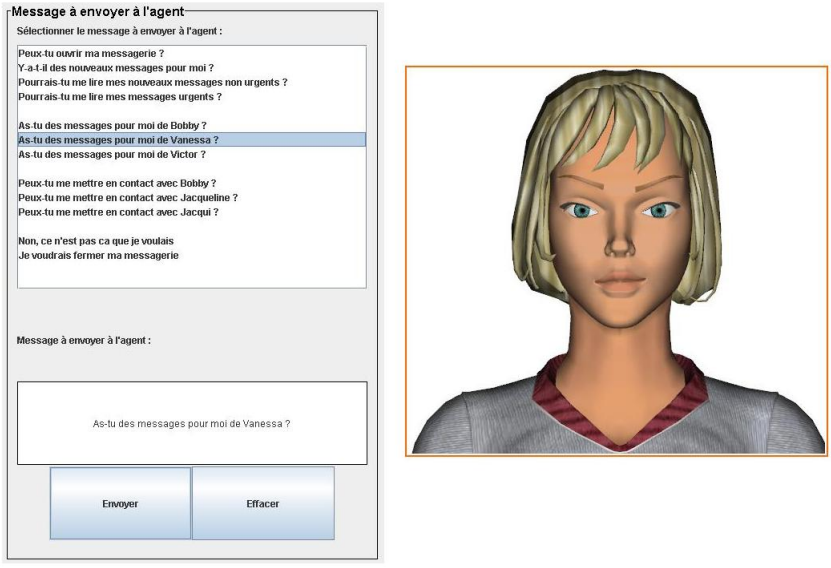

Figure 2: Screenshot of the interface of the EDAMS

1. *the non-emotional version* used as a *control condition* in which the virtual agent does not express any emotion;

2. *the empathic version* in which the virtual dialog agent expresses empathic emotions through its facial expressions during the interaction with the user. This version corresponds to the one described in the previous section. The conditions of emotions' expressions are those defined in our model of empathic emotions;

3. *the non-congruent emotional version* in which the virtual dialog agent expresses incongruous emotions to the situations of the interaction through its facial expressions. More precisely, the valence of the emotions expressed are the opposite of those in the empathic version. For instance, if, in a given situation, the virtual agent expresses an emotion of sadness in the empathic version, then, in the non-congruent emotional version, the agent expresses an emotion of satisfaction. In others words, in this version, the agent expresses a positive (respectively negative) emotion when the user potentially feels a negative (respectively positive) emotion.

In the three versions, the interface of the system (Figure 2), the verbal behavior of the agent and its facial expressions are the same. Only the conditions of emotions elicitation vary.

Eighteen subjects (nine men and nine women) have participated to the experiment. The average age was 35 (standard deviation=11.86). No participant knew the research subject and the EDAMS. During the test, each subject has performed three sequences of four or fives requests for each version of the ERDAMS. To achieve a request, the subject asked the virtual agent to execute an action by clicking on the corresponding sentence displayed on the interface (as for instance "Can you read me my new messages?"). The requests to achieve appeared in a screen on the right of the screen on which the interface of the system EDAMS was displayed. The order of the sequences and the versions were counterbalanced. The instructions to the test were presented to the participants at the beginning of the evaluation session. It explained the aim of the test as an evaluation study of their perception of the agent's facial expressions. After each sequence of tests, the subjects filled a questionnaire that enabled us to collect information on their perception of the agent.

The questionnaire to evaluate the user's perception of the virtual agent is composed of 15 affirmations: 11 regarding the virtual agent (as for example "She was pleasant") and 4 concerning more precisely her facial expressions (as for example "I have liked her facial expressions"). Finally, the

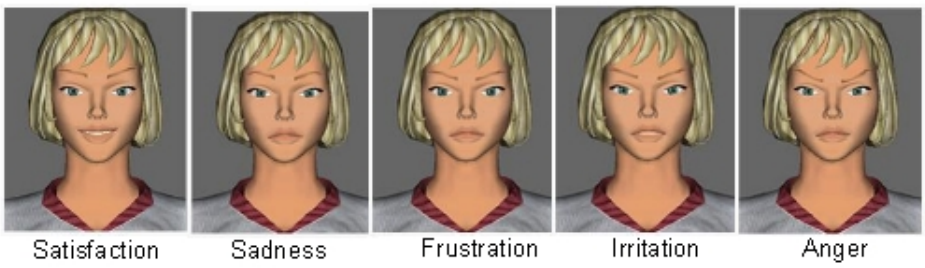

Figure 3: Facial expressions of the agent's empathic emotions

perception of the following aspects of the virtual agent have been measured: pleasant, irritating, strange, compassionate, expressive, cold, jovial, boring, strict, cheerful, stressful, appreciation of the facial expressions, natural of the facial expressions, their perturbing aspect, and their exaggerated aspect[6]. The participants have indicated their agreement or disagreement for each affirmation by checking the box corresponding to their opinion on a Likert scale of 7 points (from 1 *not agree at all* to 7 *fully agree*). At the end of the test, each participant has received a gift token to the value of 15 euros. The test for each participant has not exceeded 40 minutes.

5.2 Results

The results for each of the 15 quality factors evaluated have been analyzed separately. The distributions of the results are normal. An ANOVA of repeated measurements and a post-hoc test HSD-Tukey have been applied. In the following, these abbreviations are used to describe the different versions: *NE* for *Non-Emotional version* (no emotion displayed), *E* for *Empathic version*, and *NCE* for *Non-Congruent Emotional version*.

The results are presented in Tables 1, 2 and 3. The first column indicates the studied quality factors and the first line the versions compared; the elements of the table (*i.e.* the intersection between one line and one column) correspond to the version in which the quality factor of the agent has been the best perceived (n.s. means non significant, *: $p < .05$, **: $p < .01$, ***: $p < .001$). For instance, in Table 1, the notation E^{**} at the intersection of the line *NE-E* et the column *jovial* means that, in the empathic version, the virtual agent has been perceived significantly more jovial (with $p < .01$) than in the non-emotional one.

User's perception of the virtual agent's positive quality factors.

The analysis of the results shows an effect of the version on the user's perception of the pleasant ($F(2,34)=20.597$, $p<.001$), compassionate ($F(2,34)=7.44$, $p<.01$), expressive ($F(2,34)=4.6790$, $p<.05$), jovial ($F(2,34)=12.246$, $p<.001$), and cheerful ($F(2,34)=7.7887$, $p<.01$) aspect of the virtual agent. The significant differences appear mainly between the empathic version and the non-emotional one and between the non-congruent version and the empathic one. When the virtual agent expresses empathic emotions (positive and negative), it is perceived more jovial, expressive and cheerful than when it does not express any emotions. Moreover, when the emotions are displayed in incongruous situations, the virtual agent is perceived less pleasant, compassionate, expressive, jovial and cheerful than when the same emotions are expressed by empathy (Table 1).

	NE-E	NE-NCE	E-NCE
pleasant	n.s.	NE^{**}	E^{***}
jovial	E^{**}	n.s.	E^{***}
expressive	E^{*}	n.s	E^{***}
cheerful	E^{**}	n.s.	E^{*}
compassionate	n.s.	n.s	E^{**}

Table 1: Comparison of the user's perception of the agent's positive quality factors in the different EDAMS versions

User's perception of the virtual agent's negative quality factors.

The results reveal an effect of the version on the user's perception regarding the irritating ($F(2,34)=15.409$, $p<.001$), strange ($F(2,34)=12.518$, $p<.001$), cold ($F(2,34)=5.1405$, $p<.05$), and stressful ($F(2,34)=11.679$, $p<.001$) quality factors of the virtual agent. Significant differences appear between the non-emotional version NE and the non-congruent one NCE and between the empathic version E and the non-congruent one NCE. The virtual agent is perceived as being more irritating, strange, cold, and stressful when it expresses emotions in incongruous situations than when it displays empathic emotions or no emotion (Table 2).

	NE - E	NE - NCE	E - NCE
irritating	n.s.	NCE^{***}	NCE^{**}
strange	n.s.	NCE^{***}	NCE^{**}
cold	n.s.	NCE^{*}	NCE^{*}
boring	n.s.	n.s.	n.s.
strict	n.s.	n.s.	n.s.
stressful	n.s.	NCE^{***}	NCE^{*}

Table 2: Comparison of the user's perception of the agent's negative quality factors in the different versions

[6]No definition of these adjectives has been provided to the subjects.

User's perception of the virtual agent's facial expressions.

The results of the experiment show a significant effect of the version on the user's appreciation of the agent's facial expressions ($F(2,34)=19.324$, $p<.001$), her perception of the natural aspect ($F(2,34)=11.666$, $p<.001$), the perturbing one ($F(2,34)=14.880$, $p<.001$), and the exaggerated aspect ($F(2,32)=18.522$, $p<.001$) of the agent's facial expressions. The main significant differences appear between the non-emotional version and the non-congruent one and between the empathic version and the non-congruent one. The facial expressions of emotions incongruous to the dialog situations are less appreciated than non emotional one or those expressed by empathy. The same facial expressions of emotion are perceived more natural and less perturbing and exaggerated when they are displayed in empathic situations that in incongruous ones (Table 3).

	NE - E	NE - NCE	E - NCE
appreciation	n.s.	NE***	E**
natural	n.s.	NE***	E**
perturbing	n.s.	NCE***	NCE**
exaggerated	n.s.	NCE***	NCE**

Table 3: Comparison of the user's perception of the agent's facial expressions in the different EDAMS versions

5.3 Discussion

Firstly, the evaluation enables us to compare the user's perception of the non emotional virtual agent and the empathic one. The results show that empathic expressions of emotions do not impair the user's perception of the agent. Indeed, it does not appear more irritating, strange, cold, or stressful when it expresses empathic emotions than when it displays no emotion. Moreover, the facial expressions of emotions are not perceived less natural, more perturbing or exaggerated than non emotional ones. Some significant differences have been observed. The virtual agent appears more expressive, jovial and cheerful when it expresses both positive and negative empathic emotions than when it displays no emotion. These results allow us to confirm our first hypothesis: when a user interacts with a virtual agent to find out information in a particular domain, she perceives *more positively* the agent when the latter expresses empathic emotions.

Moreover, the results reveal that the emotions expressed in incongruous dialog situations have a negative effect on the user's perception of the agent. Indeed, she perceives the virtual agent less pleasant, more irritating, strange, cold and stressful than when the agent expresses no emotion. The facial expressions of emotions in this case seem more exaggerated and perturbing and less natural in comparison with neutral facial expressions. These results confirm our second hypothesis: when a user interacts with a virtual agent to find out information in a particular domain, she perceives *more negatively* the agent when the latter expresses incongruous emotions to the dialog situations.

By comparing the user's perception depending on the agent's conditions of the expression of emotions, it appears that the global perception of the agent depends on the congruency between the dialog situations and the expressions of emotions. Indeed, when the emotional expressions are not congruent with the dialog situations, the agent is perceived more negatively. Moreover, the same facial expressions of emotions are perceived differently depending on the conditions of emotions' expressions. They seem less natural, more exaggerated and perturbing when they are not congruent with the dialog situations than when they are displayed by empathy.

To conclude, the results of the evaluation show that a virtual agent which expresses emotions in incongruous situations is perceived more negatively than one that does not express any emotions. Inversely, when the agent expresses emotions in the conditions described in our models of empathic emotions, it is perceived more positively than when it does not express any emotion. The expressions of emotions are, therefore, in this case, *appropriate* to the dialog situations. These results validate the conditions of empathic emotion elicitation defined in our model. They are relevant to determine which empathic emotions the agent should express in which circumstances in order to enhance the user's perception of the virtual agent.

6. CONCLUSION

In this paper, we have presented a model of empathic emotions for a virtual agent based both on empirical and theoretical approaches. It enables one to provide empathic capabilities to virtual agents and more particularly to BDI-like agents. This model has been implemented as a plug-in for JSA agents (BDI-like dialog agent). From a JSA agent coupled with the module of emotions and a talking head to display the empathic emotions, a demonstration of an empathic dialog agent used as email information system has been developed in order to evaluate the impact of such an agent on the interaction with the user. The results of the evaluation show that the agent and its emotional facial expressions are perceived differently depending on the congruency between the displayed emotions and the dialog situations. Moreover, it appears that the virtual agent which expresses emotions by empathy (in the conditions described in the proposed model of empathic emotions) enhances the user's perception of the agent. These results, consistent with previous evaluations in other contexts [14, 26, 22, 5, 23], tend to promote the use of empathic virtual agent to improve human-machine interaction. However, to create a more complete model of empathic emotions, other user's goals have to be taken into account. Indeed, in the research presented in this paper, only the user's intentions related to her communicative acts are used to model the conditions of emotions elicitation.

Moreover, the model of empathic emotions and the module of emotions implemented are *a priori* domain-independent. But, the model proposed here have been constructed based on an empirical analysis of human-machine dialogs in a specific context (in which the agent is used as information system). Evaluation of the model in others contexts should be done to ensure its domain-independency.

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8. REFERENCES

[1] J. Austin. *How to do things with words*. Oxford University Press, London, 1962.

[2] C. Bartneck. *eMuu - An Embodied Emotional Character for the Ambient Intelligent Home*. PhD thesis, Eindhoven University of Technology, 2002.

[3] J. Bates. The role of emotion in believable agents. *Communications of the ACM (CACM)*, 37(7):122–125, 1994.

[4] C. Becker, I. Wachsmuth, H. Prendinger, and M. Ishizuka. Evaluating affective feedback of the 3D agent max in a competitive cards game. In J. Tao, T. Tan, and R. W. Picard, editors, *Proceedings of the International Conference on Affective Computing and Intelligent Interaction (ACII)*, Pékin, Chine, oct 2005. Springer.

[5] S. Brave, C. Nass, and K. Hutchinson. Computers that care: Investigating the effects of orientation of emotion exhibited by an embodied computer agent. *International Journal of Human-Computer Studies*, 62:161–178, 2005.

[6] N. Chovil. Social determinants of facial displays. *Journal of Nonverbal Behavior*, 15:141–154, 1991.

[7] C. Elliot. *The Affective Reasoner: A process model of emotions in a multi-agent system*. PhD thesis, Northwestern University, 1992.

[8] FIPA-ACL. http://www.fipa.org/repository/aclspecs.html, 2002.

[9] N. Frijda, A. Ortony, J. Sonnemans, and G.L.Clore. *Emotion: Review of Personality and Social Psychology*, chapter The complexity of intensity: Issues concerning the structure of emotion intensity. Sage, 1992.

[10] J. Gratch and S. Marsella. A domain-independent framework for modeling emotion. *Journal of Cognitive Systems Research*, 5(4):269–306, 2004.

[11] J. Hakansson. *Exploring the phenomenon of empathy*. PhD thesis, Department of Psychology, Stockholm University, 2003.

[12] JADE. http://jade.tilab.com/, 2001.

[13] W. Johnson, J. Rickel, and J. Lester. Animated pedagogical agents: Face-to-face interaction in interactive learning environments. *International Journal of Artificial Intelligence in Education*, 11:47–78, 2000.

[14] J. Klein, Y. Moon, and R. Picard. This computer responds to user frustration. In *Proceedings of the Conference on Human Factors in Computing Systems*, pages 242–243, Pittsburgh, USA, may 1999. ACM Press.

[15] V. Louis and T. Martinez. *Developing Multi-agent Systems with JADE*, chapter JADE Semantics Framework, pages 225–246. John Wiley and Sons Inc, 2007.

[16] S. McQuiggan and J. Lester. Learning empathy: A data-driven framework for modeling empathetic companion agents. In P. Stone and G. Weiss, editors, *Proceedings of the International joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, Hakodate, Japan, may 2006.

[17] M. Ochs, C. Pelachaud, and D. Sadek. An Empathic Rational Dialog Agent. In *International Conference on Affective Computing and Intelligent Interaction (ACII)*, pages 338–379, Lisbon, Portugal, 2007.

[18] M. Ochs, C. Pelachaud, and D. Sadek. Emotion elicitation in an empathic virtual dialog agent. In *Prooceedings of the Second European Cognitive Science Conference (EuroCogSci)*, 2007.

[19] A. Ortony, G. Clore, and A. Collins. *The cognitive structure of emotions*. Cambridge University Press, United Kingdom, 1988.

[20] E. Pacherie. *L'empathie*, chapter L'empathie et ses degrés, pages 149–181. Odile Jacob, 2004.

[21] A. Paiva, J. Dias, D. Sobral, S. Woods, and L. Hall. Building empathic lifelike characters: the proximity factor. In A. Paiva, R. Aylett, and S. Marsella, editors, *Proceedings of International joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS), Workshop on Empathic Agents*, New York, USA, aug 2004.

[22] T. Partala and V. Surakka. The effects of affective interventions in human-computer interaction. *Interacting with computers*, 16:295–309, 2004.

[23] R. Picard and K. Liu. Relative Subjective Count and Assessment of Interruptive Technologies Applied to Mobile Monitoring of Stress. *International Journal of Human-Computer Studies*, 65:396–375, 2007.

[24] I. Poggi. Emotions from mind to mind. In A. Paiva, R. Aylett, and S. Marsella, editors, *Proceedings of International joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS), Workshop on Empathic Agents*, New York, USA, aug 2004.

[25] H. Prendinger and M. Ishizuka. The empathic companion: A character-based interface that addresses users' affective states. *International Journal of Applied Artificial Intelligence*, 19:297–285, 2005.

[26] H. Prendinger, J. Mori, and M. Ishizuka. Using human physiology to evaluate subtle expressivity of a virtual quizmaster in a mathematical game. *International Journal of Human-Computer Studies*, 62:231–245, 2005.

[27] A. S. Rao and M. Georgeff. Modeling rational agents within a BDI-architecture. In *Proceedings of the International Conference on Principles of Knowledge Representation and Reasoning (KR)*, 1991.

[28] S. Reilly. *Believable Social and Emotional Agents*. PhD thesis, Carnegie Mellon University, 1996.

[29] D. Sadek. *Attitudes mentales et interaction rationnelle: vers une théorie formelle de la communication*. PhD thesis, Université Rennes I, 1991.

[30] K. Scherer. Criteria for emotion-antecedent appraisal: A review. In V. Hamilton, G. Bower, and N. Frijda, editors, *Cognitive perspectives on emotion and motivation*, pages 89–126. Dordrecht, Kluwer, 1988.

[31] K. Scherer. Emotion. In M. Hewstone and W. Stroebe, editors, *Introduction to Social Psychology: A European perspective*, pages 151–191. Oxford Blackwell Publishers, 2000.

[32] E. Tanguy, J. Bryson, and W. P. A dynamic emotion representation model within a facial animation system. Technical report, Department of Computer Science; University of Bath; England, 2005.