Expressions of empathy in ECAs

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Abstract. Recent research has shown that empathic virtual agents enable to improve human-machine interaction. Virtual agent's expressions of empathy are generally fixed intuitively and are not evaluated. In this paper, we propose a novel approach for the expressions of empathy using complex facial expressions like superposition and masking. An evaluation study have been conducted in order to identify the most appropriate way to express empathy. According to the evaluation results people find more suitable facial expressions that contain elements of emotion of empathy. In particular, complex facial expressions seem to be a good approach to express empathy.

Key words: ECA, empathy, facial expressions

1 Introduction

Recent research has shown that virtual agents expressing empathic emotions toward users have the potentiality to enhance human-machine interaction [1–3]. *Empathy* is commonly defined as the capacity to "put your-self in someone else's shoes to understand her emotions" [4]. Several empathic virtual agents are already been developed. They express empathy in different ways. For instance, in [5], the virtual agent uses specific sentences (such as "I am sorry that you seem to feel a bit bad about that question"). In [6], the facial expression is used by supposing that empathic facial expressions of emotion are similar to expressions of felt emotion of the same type. Finally, virtual agent's expressions of empathy are generally fixed intuitively and are not evaluated.

In this paper, we evaluate our model that enables an ECA to display empathic emotions. Compared to other expressive empathic agents (e.g. [6, 7]) our agent uses two types of facial expressions *simple* and *complex* ones. By simple facial expressions we intend spontaneous facial displays of emotional states (which can be described by one-word label) e.g. display of anger or contempt. The term *complex facial expressions* [8, 9] describes expressions that are the combinations of several *simple* facial displays (e.g. superposition of two emotions) or that are modified voluntarily by the displayer (e.g. masking of one emotion by another

one). Aiming at finding the appropriate facial expression of an empathic ECA we examine both types of expressions in empathic situations.

In section 2 we describe our architecture that computes the agents's empathic emotion and the expression that it will display, while Section 3 reports the results of the evaluation study we conducted.

2   Architecture of empathic agent

The process of generation of facial expressions in our empathic agent is the following. It takes as input a user's sentence. The dialog engine parses it and computes an answer for the agent. After the evaluation of what the user said, the Emotion Module computes which emotions are triggered for the agent. Finally the Facial Expressions Module computes the expression to be displayed by the agent called Greta [10]. The architecture is composed of three main modules:

1. the **Dialog Engine** is based on the JSA (Jade Semantics Agent) framework [11]. The JSA framework[4] enables one to implement BDI-like dialog agent. Such agents are able to interpret the received message and to respond to it automatically. The dialog engine contains a representation of goals and beliefs of the agent and those of its interlocutor. Depending on the received messages and on the agent's responses, the dialog engine updates the goals and beliefs.

2. Based on the goals and beliefs of both interlocutors: the agent and its interlocutor the **Emotion Module** computes the agent's emotional state [6]. Two kinds of emotions are computed: *egocentric emotions* and *empathic emotions*. The former ones correspond to the emotions of the agent, given its own goals (excepted altruist goals) and beliefs. The empathic emotions are elicited according to the goals and beliefs of the agent's interlocutor. For instance, an agent may be happy for its interlocutor because one of the interlocutor's goals was achieved (empathic emotion) and sad because one of its own goals just failed (egocentric emotion). The egocentric and empathic emotions are determined based on a *model of emotion elicitation* in which the conditions of emotion elicitation are described in terms of beliefs and goals [6].

3. The **Facial Expressions Module** computes the resulting facial expression that can either be simple or complex. The simple expressions are defined manually [13]. Complex facial expressions are generated basing on a face partitioning approach and on Paul Ekman's studies [13–16]. Each facial expression is defined by a set of eight facial areas. Expression is a composition of these facial areas, each of which can display signs of emotion. For complex facial expressions, different emotions can be expressed on different areas of the face; e.g., in sadness masked by happiness, sadness is shown on the eyebrows area while happiness is displayed on the mouth area (for details see [8, 9, 17]).

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

3 Evaluation

The main aim of this evaluation study is to verify how empathy can be expressed by an ECA. Our hypothesis is that subjects would evaluate as more appropriate the agent which expresses empathic emotions than egocentric emotion. Moreover, we want to check which type of expression: *simple* expression of empathic emotion or *complex* facial expression of *egocentric* and *empathic* emotions is more suitable. We are also interested whether these results depend on the pair of emotions used.

3.1 Scenario Set-up

Our evaluation study consists in presenting to subjects a set of scenarios and a set of animations of facial expressions of our agent. The subjects have to choose the facial expressions which are the most appropriate to the situations described in the scenarios.

Emotions. For the purpose of the experiment we wrote (in French) nine very short stories (scenarios SC1 - SC9) that were displayed to the subjects during the experiment. Each of them describes the events or situations which are intended to elicit unambiguous emotional states. In the experiment we focused on three emotional states. Our intention was to use emotions whose expressions are very different one from another so they could not be confused by the subjects. At the same time we wanted to evaluate the appropriateness of expressions of negative and positive empathic emotions. For that purpose we chose one positive emotion: *joy* and two very different negative emotions: *anger* and *sadness.*

Scenarios. The first three scenarios (SC1 - SC3) served only to show some facial expressions of Greta to subjects that probably had not seen any expressive ECA previously. These scenarios were not considered in the final result. The evaluation part is constituted of the remaining six scenarios (SC4 - SC9). They are short dialogues between two agents: Greta and Lucie. Greta and Lucie are presented to the subjects as close friends. In each scenario they meet and tell each other about events that have happened to them recently. Each scenario concerns a different pair of emotions. Thus (at least at the beginning of the scenario) emotions elicited in Greta are different from the emotions elicited in Lucie. However, the scenarios were designed to encompass situations where the empathic emotions (can) occur. For example scenario SC4 concerns the emotions of joy (Greta) and sadness (Lucie). In this scenario the following dialog is presented to the participants of the experiment:
Greta et Lucie se rencontrent dans un parc (Greta and Lucie meet in a park).
Greta : Salut Lucie ! je reviens de l'Université : j'ai eu l'examen ! Et toi ? (Hi Lucie! I just come back from the University: I pass the exam! and you?)
Lucie : Salut Greta ! Oh, et bien moi je viens d'apprendre que je ne l'ai pas eu... (Hi Greta! I have not passed the exam...)
Greta: oh!

The six scenarios SC4 - SC9 correspond to all combinations of pairs of the three emotions: anger, joy, and sadness. For each scenario SC_i there is a complementary scenario SC_j in which emotions of the two protagonists (Greta and Lucie) are exchanged.

Facial expressions. The output of the Emotion Module is composed of two labels of emotional states that correspond to the *egocentric emotion* and the *empathic emotion*. In order to evaluate the facial expressions of our agent we use different types of facial expressions. First of all the simple facial expressions of both emotions are used. We use also all plausible combinations of these emotions. Two types of complex facial expressions concern two emotional states at once: superposition and masking. Thus:

 — egocentric emotion and empathic emotion can be superposed,
 — egocentric emotion can be masked by a fake expression of empathic emotion,
 — empathic emotion can be masked by a fake expression of egocentric emotion.

The last combination is impossible in the context of our evaluation study (as the scenario is built egocentric emotion cannot be fake). For this reason we use in this study only the first two complex expressions. As a consequence, for each scenario SC4 - SC9 we generated four animations each of which shows Greta displaying one facial expression. They correspond to:

 — EXP1 - the **simple expression** of emotion E_i elicited by the Greta's event (e.g. expression of joy in SC4),
 — EXP2 - the **simple expression** of empathic emotion E_j of Greta, *i.e.* the emotion that corresponds to the emotion elicited by the Lucie's event (e.g. expression of sadness in SC4),
 — EXP3 - the expression of **superposition** of emotions E_i and E_j (e.g. superposition of joy and sadness in SC4),
 — EXP4 - the expression of **masking** of E_i by E_j, (e.g. joy masked by sadness in SC4).

The expressions of the type EXP3 and EXP4 were generated with the algorithm presented in Section 2.

3.2   Procedure

In our evaluation study we asked participants to choose the appropriate facial expressions of Greta for each scenario. To have access to a greater number of participants, we set up our experiment as a web application. One experiment session consists in going through 9 different web pages. Each of them presents one scenario and four videos. After reading the scenario on one web page, subjects can play the videos (see Figure 1). Participants view the videos in the order they wish. They can re-view animations at their convenience. In the six scenarios SC4 - SC9 they have to order the animations from the most appropriate to the less appropriate one. Each animation as well as the scenarios SC_i are displayed in a random order. The participation in the experiment was anonymous.
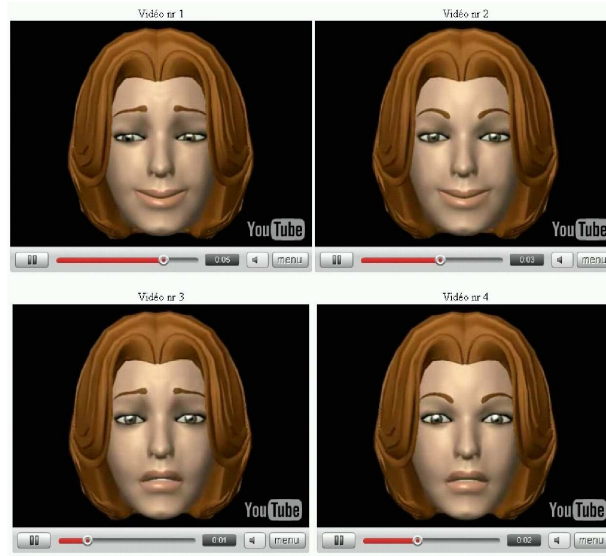
Fig. 1. The four animations displayed to the subjects (scenario SC 4)

24 persons have participated in the experiment. 44% of the participants were between 20 and 29 years old and 36% were between 30 and 39 years old. 11 participants were women, the other 13 - men.

3.3   Results

We analyzed 24 sets of answers for the scenarios SC4 - SC9. Two different criteria were applied. In the first criterion, we analyzed only the frequency of the choice as the most adequate facial expression for each type of expression. After that, in the second criterion, we considered complete subjects' answers, *i.e.* the order of animations. The results of both criteria are presented in Figure 2.
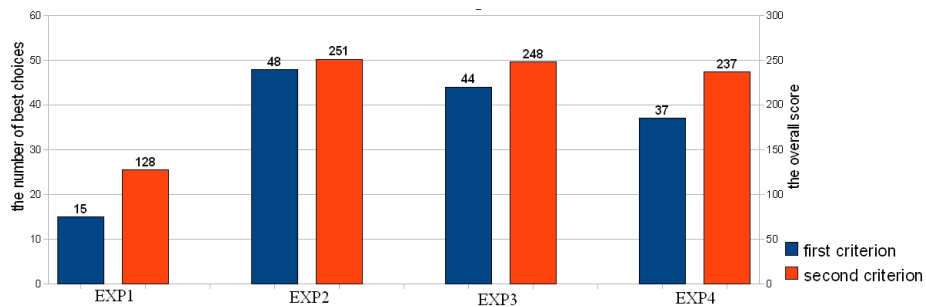

Fig. 2. The results for scenarios SC4-SC9 using both criteria

In the criterion "the most adequate facial expression" the expressions of the type EXP2 (*i.e.* simple expression of empathic emotion) was most often chosen as the most appropriate display (33%). The expression of the type EXP3 (superposition) was chosen nearly as often as EXP2 (31%). The expression of masking (EXP4) got 26%. The simple expression of egocentric emotional state (EXP1) was less often evaluated as the most appropriate one (10%).

The Friedman statistical test revealed significant difference between expressions ($p < .005$). More particularly plan comparison test showed significant difference between EXP1 and the other expressions: EXP2 ($p < .005$), EXP3 ($p < .005$), and EXP4 ($p < .005$). The difference between other pairs were not significant (EXP2 and EXP3 ($p > .05$), EXP2 and EXP4 ($p > .05$), EXP3 and EXP4 ($p > .05$)).

The difference in the evaluation of facial expressions between scenarios is significative ($p < .05$) (see Figure 3). For SC4, SC5, SC7, and SC8 the simple expression of empathic emotion (EXP2) was most often chosen. The facial expression of superposition of egocentric and empathic expressions (EXP3) was the most often chosen for the scenario SC9, while masking of an egocentric expression by an empathic expression (EXP4) was the most often chosen for the scenario SC6. There is no scenario for which the simple expression of egocentric emotion (EXP1) predominates.
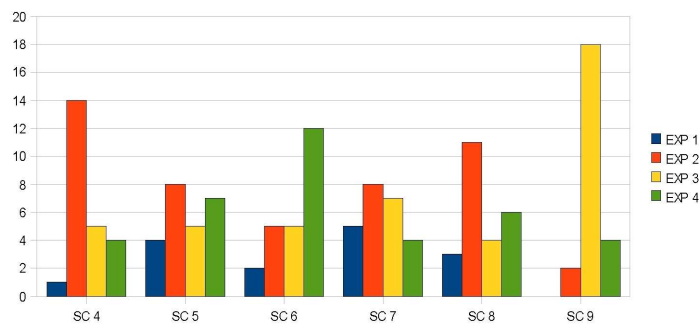

Fig. 3. The number of the most suitable expressions for each scenario

We also compare the perception of negative and positive empathic emotions. In the scenarios SC4 and SC6 the egocentric emotion of Greta is positive (i.e. joy) while Lucie's emotion is negative (sadness and anger respectively). For SC5 and SC7 the egocentric emotion of Greta is negative and Lucie's one is positive. By summing up the results for SC4 and SC6 and the results for SC5 and SC7 one can see that subjects found the expression of the egocentric emotion more adequate if this emotion is negative (9 cases vs. 3). On the contrary, for positive egocentric emotion, the expression of empathic emotion (19 vs. 16) or masking expression (16 vs. 11) is more appropriate. Wilcoxon matched pairs test showed that the difference is significant ($p < .05$).

In the second criterion we consider the order of the animations (from the most adequate to the least adequate) given by the subjects. For this purpose we introduced an index i; i is set to 3 for the most adequate expression, $i = 2$ for a second place, and so on. We sum up the values of i for each type of facial expression (EXP1 - EXP4) of SC4 - SC9. The results (see Figure 2) are similar to the results obtained for the first criterion "the most adequate solution". The Friedman test showed the significant difference between the four types of expressions (p<.005).

3.4   Discussion

The aim of our experiment was to evaluate the empathic expressions for a conversational agent. In both analyzed criteria the expressions that contained the elements of empathic emotion (*i.e.* EXP2 - EXP4) were found much more suitable than the simple expression of egocentric emotion (EXP1). Indeed, the expression of the type EXP1 was not prevailing for any scenario. Thus we can say that people expect the agent displays signs of empathy in empathic situation. Moreover, analyzing the results of each scenario separately we found that subjects considered more often the expression of negative empathic expression to be the most adequate when the egocentric state is positive than in the opposite case, *i.e.* expression of positive empathic emotion in the case of negative egocentric state. It means that the expression of negative egocentric emotion can be more justified than the expression of egocentric positive emotion in case of contradictory emotions.

We observed also that complex expressions were often evaluated as the most suitable ones. Specially superposition (EXP3) of two emotions, *i.e.* the added expressions of both egocentric and empathic emotions, was considered the most adequate nearly as often as the simple expression of empathic emotion (EXP2). On the other hand we observed differences in evaluation of facial expressions between scenarios. Thus more works appears to be needed to establish if/when complex facial expressions are an improvement. Perhaps they are particularly suitable to express empathy in certain situations (for example if both agents talk about similar arguments) or to express particular pairs of emotional states.

4   Conclusions

In this paper we presented the architecture and the evaluation study of an agent that expresses empathy. The innovation of our approach consists in using to express empathy simple expressions of emotions as well as expressions of superposition and masking. As we expected people find more suitable facial expressions that contain elements of the emotion of empathy. In particular, complex facial expressions seem to be an appropriate mean to express empathy.

In the future, we aim to continue our research on empathic expressions of ECAs. We wish to study the differences between the role of simple empathic

expression and various types (i.e. masking and superposition) of complex expressions. Various social contexts will also be considered. In the present experiment we evaluated only one type of interpersonal relations between the agents, namely between friends. We need to extend our findings to other interpersonal relationships.

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