

Warmth, Competence, Believability and Virtual Agents

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Abstract. Believability is a key issue for virtual agents. Most of the authors agree that emotional behavior and personality have a high impact on agents' believability. The social capacities of the agents also have an effect on users' judgment of believability. In this paper we analyze the role of plausible and/or socially appropriate emotional displays on believability. We also investigate how people judge the believability of the agent, and whether it provokes social reactions of humans toward the agent.

The results of our study in the domain of software assistants, show that (a) socially appropriate emotions lead to higher perceived believability, (b) the notion of believability is highly correlated with the two major socio-cognitive variables, namely competence and warmth, and (c) considering an agent believable can be different from considering it human-like.

Keywords: Virtual agent, Believability, Warmth, Competence, Personification, Emotional expressions.

1 Introduction

Virtual agents (VA) are software interfaces that allow natural, human-like, communication with the machine. The growing interest in this technology renders urgent the question concerning the characteristics that virtual agents should display. In this context the term *believability* is often used [1,2,3]. Believability is not a precise concept but many authors agree that it goes beyond the physical appearance [4,2] of the virtual agent. Rather, it includes the emotions, personality and social capabilities [5,6] of the agent. According to Allbeck and Badler believability is the generic meaning of enabling “to accept as real” ([1], p. 1). de Rosis *et al.* claim that “the believable agent should act consistently with her goals, her state of mind and her personality” ([7], p. 5) where “consistency” is interpreted as coherency between speech, nonverbal behaviors and appearance.

The authors also stress that a believable virtual agent should be able to manage its emotional expressions according to the situation in which interaction occurs [7]. The social consistency of the behaviors as one condition of believability was also postulated, for instance, by Prendinger *et al.* [8]. Other studies have shown that the agent is perceived as more believable [9] and more “human being like” [10] if its emotional expressions are adequate to the situation. Following this line of research, we investigated the effect of socially adapted emotional behavior on believability.

On the other hand, we still do not know much about which other social criteria are taken into account by users when judging believability. In this paper we argue that if people prefer and judge more believable agents able to display some social behaviors, it would seem reasonable to assume that believability is linked to socio-cognitive dimensions of the agents. To test this hypothesis we used the two main socio-cognitive dimensions identified by Fiske, Cuddy and Glick [11] as the most important dimensions of interpersonal judgment: *warmth* and *competence*.

We are also interested in how humans react socially toward agents. According to Reeves and Nass [12] people answer socially and naturally to new media. Authors claim that people automatically treat media as if they were humans. Thus, according to the Media Equation people should build social relationships with virtual agents and show a human-like attitude toward them. In this paper we call *personification* this hypothetical human-like view of the virtual agent. The relation between the notion of personification and believability in virtual assistants is an interesting issue rarely analyzed so far. In [13,14] personification is strictly related to the presence of the agent. Authors have evaluated the role of the physical presence in the communication and learning experience. However, they do not put attention on social relations with the agent. In our work we rather focus on the attribution of human mental features and the creation of a human-like attitude toward the agent.

In this paper we present an experiment in the virtual assistant’s domain. This experiment had three distinct objectives. Firstly, we wanted to show that a believable agent needs not only to communicate emotional states but must also express socially adapted emotions. Secondly we checked the relation between VA believability and two of the most important socio-cognitive factors considered in human intersubjective judgments [11], namely competence and warmth. Finally, we examined the difference between believability and personification.

2 Emotionally Expressive Virtual Agents

Several works have studied the role of appropriate emotional displays on the perception of virtual agents. Unadapted emotional displays may influence the user’s evaluation of the agent negatively. In the experiment of Walker *et al.* people liked the facial interface that displayed a negative expression less than the one which showed a neutral expression [15]. However, it does not mean that negative expressions are not desirable at all. In a card game the agent that

displayed only positive expressions, irrespectively of the situation, was evaluated worse than the one that also expressed negative emotions [10]. These results suggest that the choice of emotional displays influences the perception of agents' believability. They also highlight the role of the context in the judgment. Indeed, several studies have focused on the appropriateness of emotional displays in the social context. Lim and Aylett [9] developed the PDA-based Affective Guide that tells visitors stories about different attractions. The evaluation results found that the guide that used appropriate emotional displays and attitude was perceived to be more believable, natural, and interesting than the agent without emotional displays and attitudes.

Prendinger et al. showed the influence of facial expression management in the perception of "naturalness" of the agent [8]. They introduced a set of procedures called "social filter programs" that define the intensity of an expression as the function of a social threat, user's personality, and the intensity of emotion. Consequently, their agent can either increase or decrease the intensity of facial expression, or even totally inhibit it.

Niewiadomski *et al.* [16] studied the appropriate emotional displays of a virtual agent in empathic situations. In a set of scenarios, the authors compared their agent displaying the "egocentric", "empathic" emotions and the two different complex facial expressions of both emotional states. In the evaluation study, facial expressions containing elements of the empathy emotion (i.e. "empathic" or complex expressions) were considered more adequate.

All of these studies demonstrate the importance of adapting the emotions of the agents to contextual information. In our study we go further, we distinguish three levels of emotional behaviors and take into account their *appropriateness* and *plausibility*. This will be explained in greater detail in section 5.

3 Relation between Believability, Competence and Warmth

The second purpose of this paper is to better understand what kind of factors people take into account when judging the believability of a virtual agent. As seen in the previous section, a shared opinion concerning the believability of agents is that social factors are crucial. It seems thus quite reasonable to assume that the notion of believability is linked to some socio-cognitive dimensions of the agents. In this paper we focus mainly on two socio-cognitive dimensions that describe most human intersubjective judgments: competence and warmth [11,17].

Fiske et al. explained that warmth and competence are the two prior variables evaluated by people when encountering another person: "when people spontaneously interpret behavior or form impressions of others, warmth and competence form basic dimensions that, together, account almost entirely for how people characterize others." ([18], p.77). The *warmth* dimension is defined as capturing "traits that are related to perceived intent, including friendliness, helpfulness, sincerity, trustworthiness and morality", while *competence* "traits

that are related to perceived ability, including intelligence, skill, creativity and efficacy” ([11], p.77).

To determine whether the judgment of the agent’s believability is related to socio-cognitive traits of the agent, we evaluate in this paper whether people judge virtual agents using these two dimensions. The correlation between judgment of these two factors and judgment of believability is also tested. It will enable us to determine whether people tend to refer to the same variables while judging agents and people. This second observation raises the question of the relation between believability and personification. We discuss this topic in more detail in the next section.

4 Believability and Personification

Reeves and Nass [12] conducted a set of experiments showing that people tend to act socially with new media and treat media as if they were real people. For example, they showed that people tend to give better evaluation to the software when they answer the satisfaction questionnaire on the same computer as the one they used during the experiment. The authors explained this phenomenon by claiming that the subjects do not want to offend the computer. The concept explored in that study goes along what we defined in section 1 as personification. In both cases it tackles idea of considering an agent as a real human and having a human-like attitude toward it.

One may think that if people tend to judge more believable the agents that looks [19] and behave like humans (e.g. by displaying emotions or using politeness [20]) it means that believability and personification are two equivalent concepts. However, in our opinion the creation of a believable agent (i.e. an agent that looks and behaves like a real human being) is different from creating a human-like relation with it. Furthermore, a recent study of Hoffmann *et al.* [21] called some of Reeves and Nass’ results into question by showing that when people behaved politely toward the computer, they actually thought of the programmer.

To check our hypothesis, in our experiment we used an ambiguous statement that can be understood differently in the context of human-human and human-machine interaction. We explain this in greater detail in the next section.

5 Experiment

In our experiment, we simulate a typical virtual assistant scenario. In the scenario presented to the participants, the protagonist of the story is using a new computer equipped with the virtual agent. The agent may assist in the user’s tasks, it can also give the advices and the comments. The system is also equipped with some card games that can be played by the protagonist. Our experiment starts when the “hypothetic” user loses the game. We ask the participants of the experiment about their opinions on the reactions of the virtual agent to this situation. Even in this simple situation there are many factors that may influence the perception of agent’ believability. In the experiment we consider the

following factors: the emotional reactions of the agent and the modalities (i.e. verbal or/and nonverbal) used to communicate them, and the agent's goal strategy. Operationalization of each variable and manipulation check are described below.

In our experiment we distinguish between the appropriateness and the plausibility of emotional behaviors. *Appropriateness* refers to the fact that the emotion meets social expectations of what people are supposed to feel in the situation. For example, an expression of sadness *is expected* (i.e. is appropriate) in our context (in the sense of the OCC model [22]) because the user loses the game. The *plausibility* of an emotional state refers to the fact that an emotion can be displayed in the situation even if it is not the appropriate one. In the game context the happiness reaction is still plausible e.g. as an ironic reaction, but is not (socially) appropriate. Finally, fear is neither (socially) appropriate nor plausible in this context.

The choice of the three emotions (sadness, happiness and fear) used in the experiment follows the OCC model of Ortony, Clore and Collins [22]. The OCC model predicts that the adapted emotion to be displayed when something (event-based) happens to someone else (fortunes of others) is either happiness or sadness depending on the valence of the event. In our experiment, the event has a negative valence (the loss of the game), we thus choose sadness as the appropriate reaction, and happiness as the inappropriate one. The fear was chosen to be a totally misfit emotion, never appropriate in the context, no matter the valence of the event. A manipulation check was conducted to test the appropriateness and plausibility of each of these three emotional reactions (see section 5.4).

To obtain more precise results about the effect of emotions, we distinguish between verbal emotional reactions and nonverbal emotional reactions. This distinction was made in order to evaluate the effect of multimodality of emotional expression on agents' believability.

The *personification* of the agent was evaluated through the interpretation of the ambiguous statement "Are you sure you want to quit?". The manipulation check shows that this statement is interpreted differently depending on whether it is expressed by a computer or a human. Indeed, this statement is often used by computers when the user clicks on the cross button to close an application. In this case it is interpreted as a simple check to make sure it is not a mistake. If expressed by a human, on the other hand, the sentence may communicate the willingness not to finish the interaction (see section 5.4 for detailed results of the manipulation check).

Finally, as a control variable, the goal of the virtual agent was also manipulated. In one condition the agent was identified as "assisting the user in the task", while in the other condition, it had no obligation to support user's activity. This factor was included to ensure that this distinction has no effect on the warmth judgment (a socially appropriate emotional reaction, if perceived as forced by the context, could decrease the warmth judgment, and thus, possibly, believability).

In the following sections we present our hypotheses, the set-up of the experiment, manipulation check, results and their discussion.

5.1 General Hypotheses

We tested three main hypotheses:

- H1: A virtual agent will be judged warmer, more competent and more believable when it displays socially adapted emotions;
- H2: Judgment of believability will be correlated with the two socio-cognitive factors of warmth and competence;
- H3: Judging an agent as believable is different from creating a human-like relation with it.

5.2 Method

The experiment was placed on the Web. The interface was composed of a set of pages illustrating the plot of a session with a software assistant. Each page corresponds to an event, it may contain an animation or a picture of the agent. We generated a set of animations corresponding to events of the prescribed scenario. The subjects could not influence the plot of the scenario, they saw the animations and answered the related questions. The scenario had two versions corresponding to two different strategies used by the agent: “task-centered” (TC) and “user-centered” (UC). The difference between these two versions of the experiment was limited to verbal content. The plot of the scenario along with the nonverbal behaviors displayed by the agent were the same. Each session was composed of two sections. In each section the user was asked to answer some questions concerning the behavior of the agent. In the first section (S1) the questions concerned hypotheses H1 and H2, while the second section (S2) was related to hypothesis H3. During the experiment each subject participated in at least 5 and at most 10 sessions, all belonging to one variation of our scenario (TC or UC).

In the scenario, participants were asked to imagine that they possessed a new computer including a virtual assistant. At the beginning of the experiment the respective version of the scenario (TC or UC) was explained to the participants.

In more detail, participants answering the “user-centered” questionnaire read that the context of the experiment was the following:

“You decide to try a new game that is included with your new computer, the agent is here to explain you the rules and give you some advices on how to play. You play a game and lose”.

In the “task-centered” group a different explanation was presented which legitimate the presence of the agent that does not support the user activity:

“You open a new document for work, the agent explains the new functionality of the tool. After a few moments, you decide to take a break and open a game included with the computer. In the meantime, the agent is displayed on the screen. You play a game and lose”.

In section S1, videos show virtual agent’s reactions immediately after the user’s defeat. For section S1 we generated 20 different animations of VA. Ten of them corresponded to user-centered strategy and ten others to task-centered strategy (see section 5.3).

After watching each video, participants were asked to judge the competence of VA (question Q1), its warmth (question Q2), and its believability (question Q3) on three separate 7 point-scales (from *not at all* to *entirely*). The participants were also asked to explain in a few words their choice concerning question Q3.

To explore the differences between believability and personification, the second part (S2) of the experiment was used. Sections S1 and S2 were split by a separate page with the explanation. The second section (S2) of the experiment corresponds to the final part of the scenario. We asked the subjects to imagine that they are tired and want to quit the application by clicking on the cross button. One video was used in section S2. On this video the agent asks with a neutral voice “Are you sure you want to quit?” According to the hypothesis discussed above in this section this ambiguous statement can be interpreted differently depending on the type of relation between the user and the agent. Participants had to choose (question Q4) if the agent’s intention was only to verify that they did not click on the cross button by error (literal interpretation), or if its intention was to tell them in an implicit way not to break the interaction (indirect interpretation).

104 online volunteers participated, all native French speakers (33 men, age range 19-60, mean = 29.3, SD = 9.7). They were randomly assigned to one of the two experimental groups [user-centered (UC) vs. task-centered (TC)].

5.3 Videos

In each version of the scenario (TC/UC) one of the following videos was displayed randomly in section S1:

- 3 videos of VA displaying a socially appropriate and plausible emotional reaction (condition A&P); the emotion displayed by the agent was sadness;
- 3 videos of VA displaying a socially inappropriate but plausible emotional reaction (condition NA&P); the emotion displayed by the agent was happiness;
- 3 videos of VA displaying a socially inappropriate and implausible emotional reaction (condition NA&NP); the emotion displayed by the agent was fear;
- 1 video of VA with no reaction at all (condition NE).

In the videos containing (non) appropriate and/or (non) plausible emotional reactions, one of them showed the agent displaying both verbal and nonverbal emotional reactions, one showed the agent displaying only verbal emotional reaction and one showed the agent displaying only nonverbal emotional reaction.

We used in the experiment a pre-recorded human voice with a prosody corresponding to the illustrated emotional state. The emotional nonverbal behavior of the agent was composed of facial expressions accompanied by emotional gestures.

5.4 Manipulation Check

A manipulation check was conducted with an independent sample of 40 volunteer students of the University of Toulouse le Mirail.

Four paper and pencil questionnaires checked both the appropriateness and plausibility of three emotional reactions used in the experiment (sadness, happiness and fear) under task-centered and user-centered conditions, and the interpretation of the ambiguous statement “Are you sure you want to quit?” expressed either by a computer or by a human being.

The participants were presented a short story. The story corresponded to the scenario presented in the real experiment but in the manipulation check the virtual agent was replaced by the human being. The participants were told to imagine they were testing a new game during video-game show in the presence of the presenter. In the user-centered condition (UC) the presenter was willing to explain the rules of the game while in the task-centered one (TC) he only observed. Similarly to the scenario used in the real experiment, participants were told they have lost their game.

Participants were then asked to judge the appropriateness and plausibility of each of the 3 statements used in the experiment (the one expressing sadness, the one expressing happiness and the one expressing fear) on the same three separate 7-point scales as used in the experiment. They were also asked to interpret the ambiguous question Q4.

Results were analyzed using ANOVA for the judgment of appropriateness and plausibility and with a Mann-Whitney for the interpretation of the ambiguous statement. The results of the ANOVA show that people tend to judge sadness as appropriate (mean = 3.90, $SD = 1.97$) and plausible (mean = 4.45, $SD = 1.88$). Happiness is perceived as less appropriate (mean = 3.03, $SD = 1.97$) $F(1, 39) = 3.98$, $p = .05$ but plausible (mean = 4.43, $SD = 2.07$), and fear as neither appropriate (mean = 1.65, $SD = 1.25$) $F(2, 38) = 32.63$, $p < .0001$ nor plausible (mean = 1.98, $SD = 1.31$), $F(2, 38) = 21.36$, $p < .0001$.

The results of the Mann-Whitney test show that people interpret more often the ambiguous statement as a literal question (Mean Rank = 15.5) when expressed by the computer and as an implicit way to telling them not to exit the game (Mean Rank = 25.5) when expressed by a human, $z = -3.12$; $p < 0.006$; one-side.

No effect of the goal (TC vs. UC) was detected (the between subject ANOVA: $F(1, 36) = 2.57$, $p = .092$).

5.5 Results

During the experiment we collected 3973 answers. No effect of the goal of the agent was detected (TC vs. UC condition), $F(1, 100) = 0.39$, $p = .84$, we thus conducted the following analysis with the entire sample of participants. Descriptive results for all experimental conditions are displayed in Table 1.

Impact of socially adapted emotion on believability, competence and warmth: Results were analyzed with a within-subject ANOVA and revealed an

Table 1. Judgment of competence, warmth and believability in each emotional experimental condition. Standard deviations appear in parentheses.

	Participants' judgments		
	Competence	Warmth	Believability
<i>Condition A&P</i>			
Behavior: Multimodal	3.64 (1.83)	4.05 (1.77)	3.81 (1.77)
Behavior: Verbal	3.11 (1.60)	2.76 (1.62)	3.19 (1.70)
Behavior: Nonverbal	3.07 (1.69)	3.32 (1.70)	3.55 (1.76)
<i>Condition NA&P</i>			
Behavior: Multimodal	2.89 (1.64)	2.49 (1.64)	2.84 (1.73)
Behavior: Verbal	3.15 (1.73)	2.64 (1.66)	3.14 (1.83)
Behavior: Nonverbal	2.3 (1.36)	2.19 (1.63)	2.26 (1.58)
<i>Condition NA&NP</i>			
Behavior: Multimodal	3.02 (1.68)	3.28 (1.64)	2.73 (1.63)
Behavior: Verbal	2.79 (1.46)	2.70 (1.46)	2.74 (1.52)
Behavior: Nonverbal	2.68 (1.58)	2.76 (1.44)	2.79 (1.58)
<i>Condition NE</i>			
Behavior: None	1.72 (1.28)	1.55 (1.13)	2.05 (1.60)

effect of socially adapted emotion on believability $F(3, 95) = 22.77$, $p < .0001$, $\eta^2 = .11$ ¹, competence $F(3, 95) = 37.69$, $p < .0001$, $\eta^2 = .14$, and warmth $F(3, 95) = 51.71$, $p < .0001$, $\eta^2 = .22$.

The results show that participants consider the agent more believable in the socially appropriate and plausible condition (A&P) (mean = 3.50, $SD = 1.20$) than in the socially inappropriate but plausible condition (NA&P) (mean = 2.73, $SD = 1.21$) ($p < .0001$), the inappropriate and implausible condition (NA&NP) ($p < .0001$) (mean = 2.76, $SD = 1.18$), and the no reaction condition (NE) (mean = 2.05, $SD = 1.60$) ($p < .0001$). The difference between plausible (NA&P) and non plausible (NA&NP) reaction is not significant ($p = .82$), but the no reaction condition (NE) differs significantly from all other conditions ($p < .0001$).

The perceived competence of the agent's behavior also significantly increases with the social appropriateness and plausibility. The mean value of competence judgments drops from 3.28 ($SD=1.26$) in the appropriate and plausible condition (A&P) to 2.67 ($SD=1.18$) in the inappropriate and plausible condition (NA&P) ($p < .0001$) and to 1.72 ($SD=1.28$) in the NE condition ($p < .0001$). However, people judge the agent more competent when it behaves in an implausible way (NA&NP) (mean = 2.86, $SD = 1.27$) ($p < .04$) than in the (NA&P) condition.

Judgment of warmth follows the same pattern as in the case of competence. The mean value of warmth judgments drops from 3.37 ($SD=1.24$) in the appropriate and plausible condition (A&P) to 2.43 ($SD=1.25$) in the inappropriate and plausible condition (NA&P) ($p < .0001$), and to 1.55 ($SD=1.13$) in the condition NE ($p < .0001$). Again, people judge the agent warmer when it behaves

¹ (we report *semi partial* η^2 values, which are more appropriate and more conservative when using within-subject ANOVA).

Table 2. Minimum and maximum correlation scores between believability, competence and warmth

	Believability	Competence	Warmth
Believability	1	.555/.855	.510/.787
Competence	.555/.855	1	.498/.745
Warmth	.510/.787	.498/.745	1

in a non plausible way (NA&NP) (mean = 2.92, $SD = 1.18$) ($p < .001$) than in the (NA&P) condition.

In addition to these global results, a finer analysis using a within-subject ANOVA shows that socially adapted emotional behavior has more impact on believability, competence and warmth when expressed both verbally and non-verbally than verbally alone, and nonverbally alone. $F(1, 95) = 6.56$, $p = .012$, $\eta^2 = .02$ for judgment of competence, $F(1, 95) = 15.36$, $p < .0001$, $\eta^2 = .04$ for judgment of warmth, and $F(1, 95) = 4.55$, $p = .035$, $\eta^2 = .02$ for judgment of believability.

For all three judgments (i.e. believability, warmth and competence), the verbal and nonverbal display of emotion was significantly higher than those of verbal alone (respectively $p < .008$, $p < .0001$ and $p < .01$) and nonverbal alone respectively $p = .051$, $p < .0001$ and $p < .01$). No significative difference was found between the two last conditions (respectively $p = .26$, $p = .056$ and $p = .74$).

Socio-cognitive believability: The results also show a high correlation between believability, competence and warmth. Pearson's correlation scores were calculated for each experimental situation. Table 2 displays the minimum and maximum correlation scores between believability, competence and warmth. All reported correlations are significative ($p < .001$).

Believability and personification: The last hypothesis deals with the link between believability of the virtual agent and it's personification.

To assess the correlation between judgment of believability and interpretation of the ambiguous statement we introduce an index (i_{is}) to calculate "the interpretation score". Each answer for the question Q4 got a score: 1 for a literal interpretation and 2 for in indirect one.

To calculate the correlation between the believability and personification we use three interpretation score indices ($i_{is(A\&P)}$, $i_{is(NA\&P)}$, $i_{is(NA\&NP)}$) - one for each experimental condition: A&P, NA&P, and NA&NP. The value $i_{is(n)}$ in the condition n for the user m is a sum of the scores received in three sessions corresponding to three videos (verbal, nonverbal, multimodal) in section S1. Thus, in each condition, each participant has associated the interpretation score indices $i_{is(n)}$, $n \in \{A\&P, NA\&P, and NA\&NP\}$ - i.e. three values ranging from 3 to 6. A score of 3 indicates that the participant always interpreted the statement literally while a score of 6 that he/she always interpreted it indirectly. In other words, the higher the score $i_{is(n)}$ is, the higher the personification is.

The correlation between believability (question Q3) and personification (index $i_{is(n)}$) was calculated separately for the conditions A&P, NA&P, and NA&NP. The results of the Pearson's correlation do not show any significant correlation between believability and personification $+0.13$ ($p = .18$) for the A&P condition, -0.05 ($p = .62$) for the NA&P condition, and -0.14 ($p = .15$) for the NA&NP condition).

6 Discussion

The results clearly support our hypotheses. Firstly they show the effect of socially adapted emotional expressions on believability, warmth and competence. Secondly, they show a high correlation between these three variables. This leads us to think that these two main socio-cognitive variables are used to judge agents' believability. Finally, the results show that, even if people use the same socio-cognitive variables to judge agents and human being, the notion of believability is not correlated to the agent's personalization.

In more detail, considering hypothesis H1, the perception of believability, warmth and competence is related to the emotional reactions presented by the agent. In the same situation the agent expressing appropriate and plausible emotional reactions (A&P) was considered more believable, more competent and warmer than the other agents (NA&P, NA&NP, NE). The agent showing non appropriate but plausible emotional states (NA&P) was more believable than the one showing implausible emotions (NA&NP) or no reaction (NE) at all. It (NA&P) was also considered less warm and less competent than the agent showing implausible emotions (NA&NP). This effect may be explained by the fact that inappropriate emotional displays may have very strong negative impact on the users, which is stronger than the effect of showing emotions that are not related at all to the situation (i.e. implausible). This result is also somewhat consistent with some previous works [10,15] (see section 2). Any reaction (appropriate/plausible or not) was better evaluated than no reaction at all.

Believability, warmth and competence also increase with the number of modalities used by the agent. The agent that uses appropriate verbal (speech, prosody) and nonverbal (facial expressions, gestures) communication channels is more believable than the one using only speech with prosody or only facial expressions and gestures. Thus, the more expressive the agent is the more believable it is.

Regarding hypothesis H2 it was shown that the perception of warmth and competence are correlated with the perception of believability. It indicates that judgment of believability is linked to these two socio-cognitive variables and thus that socio-cognitive factors are taken into account while evaluating the agent's believability.

Regarding hypothesis H3 we did not find any correlation between the personification of the agent and the perception of believability. A number of factors, however, could influence this result. First of all, even in the A&P condition the mean value for the perception of the believability wasn't very high (maximum score = 3.81). We cannot exclude that personification occurs only when believability is very high (the agent is "completely believable"). Moreover the duration

of the session could have been too short to generate a human-like relation between the user and the agent. Finally, during a real interaction, a user unaware of the laboratory setting may behave indifferently to the one who is explicitly asked in the experimental setting to choose the interpretation. Because of this, the relation between the believability of the agent and the human-like attitude toward it should be studied more deeply in the future.

6.1 Implication for VA' Emotional Behavior

Our results replicate previous findings showing that emotional agents are judged more believable than non emotional ones. They provide more accurate results, however, since they show that adding emotional displays is not sufficient to guarantee an improvement in agent believability. The context in which the emotion is expressed must also be taken into account. According to these results, believable virtual agents should be able to adapt their emotional displays to the context. To be able to behave in a socially adapted way, agents should be able to take into account contextual factors and decide which emotion is appropriate to the situation. Further investigations in this direction are necessary to endow an agent with such skills. More modestly, our results also show that displaying emotions both verbally and non verbally may improve the perception of agent's believability. This result should be taken into account in the design of future virtual agents.

6.2 Implication for the Concept of Believability

The results of our experiment have two implications for the concept of believability. Firstly, it appears that the notion of believability needs to be distinguished from the one of personification (at least for agent with moderate believability rate). Secondly, believability is highly correlated to the two major socio-cognitive dimensions of warmth and competence.

The warmth and competence results are consistent with previous findings in human/human judgments: (a) both judgments are positively correlated as shown in [23,24]; (b) the highest effect size of warmth judgment is consistent with the idea of a primacy of warmth judgment [25]. It seems that people use the same pattern while judging virtual agents and humans. However, it does not mean that they create a human-like relation with them. Indeed, the absence of correlation between believability and personification indicates that these are two distinct concepts.

Finally, the believability rate and free comments given by participants (question Q3 of the experiment) also reveal improvements to bring to virtual agent animation. According to some comments low quality of the physical appearance and especially the lack of fluidity of the agent's animations may also cause the lower believability. Thus physical appearance and social factors must be taken jointly into account to create more believable agents able to maintain interaction with users.

7 Conclusion

In this paper we analyzed several factors influencing the perceived believability of a virtual assistant. In the experiment we showed that to create a (more) believable agent, its emotional (verbal/nonverbal) behavior should be socially adapted. We showed also that two main socio-cognitive factors: warmth and competence are related to the perception of believability. We also suggested that even if the agent is perceived as “believable” it does not imply that humans will create “human-like” relations with it.

In the future, we plan to continue our research on believability. We would like to study in more detail the relation between believability and personification. The results presented in this paper are limited to the software assistant domain. We would like to verify our hypotheses also in other virtual agent applications.

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