Model of the Perception of Smiling Virtual Character

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ABSTRACT

A smile may convey different communicative intentions depending on subtle characteristics of the facial expression. Moreover, during an interaction, the expression of smile impacts on the observer's perception of both the social stance of the speaker and of the content of the talk. In this paper, we describe a perceptual study where we explore the effects of virtual characters displaying different types of smiles (namely politeness and amusement) when speaking on the user's perception. Based on the collected data, a model to automatically compute the user's potential perception of the virtual character's social stance depending on its smiling behavior and on its gender has been proposed.

Categories and Subject Descriptors

H.5.1 [**Multimedia Information Systems**]

General Terms

Algorithms

Keywords

Virtual character, smile, user's perception

1. INTRODUCTION

During dialog, non-verbal behaviors play an important role on interlocutor's perception. The content of the message but also the global stance of the speaker may be perceived differently depending on her gestures, her posture, and her facial expressions. For instance, smiles may enhance the global perception of a person [6, 18, 27] and even of a virtual character [14]. In this paper, based on a human-centric approach, we propose to explore the effects of smiles on the perception that users have of a virtual character.

A smile is one of the simplest and most easily recognized facial expressions [9]. To create a smile, the two muscles zygomatic majors, on either side of the face, have to be activated. However, others muscles may be implied in an expression of smile. Moreover, a smile may have several meanings - such as amusement and politeness - depending on subtle differences in the characteristics of the smile itself and of other elements of the face that are displayed with the smile. These different types of smiles are often distinguishable during a social interaction. Recently researchers [26, 22] have shown that people are also able to distinguish different types of smiles when they are expressed by a virtual character.

A smiling virtual character improves human-machine interaction. For example it enhances the perception of the task to be done and how the character is perceived. It increases the motivation and enthusiasm of the user [14, 31]. However, an inappropriate smile (an inappropriate type of smile or a smile expressed in an inappropriate situation) may have negative effects on the social interaction [31].

In this paper, we present research that aims at identifying the effects of different virtual character's smiles on the user's perception of the virtual character. More precisely, we have investigated how polite and amused smiles displayed by speaking virtual characters alter the user's perception both of the content of a message and of the stance of the virtual character. We considered the types of displayed smile and the gender of the virtual character. For this purpose, we propose a *human-centric approach* to both identify the characteristics of smiles and their effects on perception. We have first identified the dynamic and morphological characteristics of different types of virtual character's smile. Our method was to collect a corpora of smiles directly created by users. Characteristic features of each smile types were extracted from the analysis of the corpora. An evaluation study has been conducted to validate the identified smiles in context. Secondly, we have developed a web application to collect the user's perception of virtual characters displaying different smiles when saying an utterance. Two types of smile have been considered: polite and amused smiles. Two virtual characters, a female and a male one, were used. The results have been used to propose a model to automatically compute how user's (potential) perception of the agent is influenced dynamically by the display of agent's smile. It is a first attempt toward being a Theory of Mind model. The Theory of Mind is the cognitive ability to understand others' actions and expressions within an intentional or goal-directed framework (i.e. the *intentional stance* [5]). In our work, based on a human-centric approach, we aim at modeling the user's Theory of Mind of the agent's social stances.

The paper structure is as follow. After giving an overview of existing works on humans' smiles and on virtual characters' smiles (Section 2), we introduce the method used to identify the different types of smile of virtual characters (Section 3). In Section 4, we present the web application

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developed to collect the user's (potential) perception of a smiling virtual character. In Section 5, we present the resulting data and we introduce a model to compute the user's perception of a smiling virtual character during an interaction. We conclude and present perspectives of this research in Section 6.

2. RELATED WORK

In this section, we present existing research on the types and meaning of smiles (Section 2.1) and the effect on the observer (Section 2.1), both in human-human interaction (Section 2.1.1 and 2.2.1) and in human-machine interaction (Section 2.1.2 and 2.2.2).

2.1 Types and meaning of smiles

2.1.1 Human smiles

According to Poggi and Chirico [24], a smile may have two basic meanings: "a purely expressive meaning, an expression of pleasure, and a communicative meaning, the goal of showing friendly to other people". Smile can also replace a word: one can smile to say "hello" [24].

The most common type of smile is the *amused smile*, also called felt, Duchenne, enjoyment, or genuine smile. Another type, which is often thought of as the amused smile's opposite is the *polite smile*, also called non-Duchenne, false, social, masking, or controlled smile [11]. Perceptual studies [11] have shown that people unconsciously and consciously distinguish between an amused smile and a polite smile. Other smiles have been identified, as for instance embarrassed smiles. However, in the current paper, we focus on two smiles: the amused and polite smiles.

These different smiles are distinguishable by their distinct morphological and dynamic characteristics. Despite, no consensus exists on the morphological and dynamic characteristics of the amused and polite smiles, it is, in general believed that the orbicularis oculi (which refers to the Action Unit (AU) 6 in the Facial Action Coding System [10]) is more present in amused smile than in polite smile. The dynamic characteristics of the amused smile are the smoothness and regularity of the onset, apex, offset (describing the temporal course of the facial action) and of the overall zygomatic actions, the mouth opening. The duration of the smile lasts between 0.5 and 4 seconds [1, 9]. In the expression of a polite smile, the cheek raising (AU6) is absent, the amplitude of the zygomatic major (AU12) is small, the smile is slightly asymmetric, the apex is longer, the onset shorter, the offset is more abrupt than in amused smile, and the lips may be pressed [9].

2.1.2 Virtual smiles

In order to increase the repertoire of communicative behaviors of virtual character's facial expressions, several researchers have considered different virtual character's smiles. For instance, in Tanguy [30], two different types of smiles, amused and polite, are used by a virtual character. The amused smile is used to reflect an emotional state of happiness whereas a polite smile, called fake smile in Tanguy (2006), is used by the virtual character masking sadness with a smile. The amused smile is represented by lip corners raised, lower eyelids raised, and an open mouth. The polite smile is represented by an asymmetric raising of the lip corners and an expression of sadness in the upper part of the face. In Rehm and André [26], virtual characters mask a felt negative emotion of disgust, anger, fear, or sadness with a smile. Two types of facial expression were created according to Ekman's description [8]. The first expression corresponds to a felt emotion of happiness (including an amused smile). The second one corresponds to the other expression (e.g. disgust) masked by unfelt happiness. In particular, the expression of unfelt happiness lacks the AU6 activity and is asymmetric. It may correspond to a polite smile. Niewiadomski and Pelachaud [21] proposed an algorithm to generate complex facial expressions, such as masked or fake expressions. An expression is a composition of eight 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. In particular, it is possible to generate different expressions of joy: a felt and a fake one. The *felt* expression of joy uses the reliable features (AU6), while the second one is asymmetric.

Several other virtual characters smile during an interaction to either express a positive emotion [25], to create a global friendly atmosphere [31], or for salutation [4]. Generally, these virtual characters use only the amused type of smiles. In this present work, we explore different types of smiles a virtual character may perform.

2.2 Perception of smiles

2.2.1 Human-human interaction

Several studies have shown that individuals who smile are perceived more positively than non-smiling persons. Smiling people are viewed as more relaxed, kind, warm, attractive, successful, sociable, polite, happy, honest with a higher sense of humor, and less dominant [6, 7, 18, 20, 27].

In Western society, the women smile more than men and are also expected to do so [6, 17]. For instance, in Deutsch, LeBaron, and Fryer [6], a study of the perception of photography of male and female smiling and non-smiling faces show significant differences depending on gender. Whereas there is no significant difference between smiling men and women, the absence of smile for a woman seems to deteriorate her image compared to a man. Indeed, the study has shown that women who do not smile are perceived less happy and relaxed than non-smiling men. The hypothesis is that different standards are applied to evaluate non-verbal behavior of men and women. People expect that women smile more than men, and consequently, a deviation from that expected behavior influences negatively the perception of non-smiling women. No distinction between polite and amused smiles is considered in the study. Moreover, as shown in Hess, Blairy, and Kleck [12], since smile is expected for a woman, perceiver may not consider women's smiles as informative compared to men. Moreover, research has shown an influence of gender on the perception of the intensity of a smile: men's amused smiles are perceived as more intense than those of women.

Concerning the detection of different smile types, research has shown that women are more sensitive to non-verbal signs and more able to decode facial expressions cues, even for virtual characters' faces [15]. Women make more extreme judgment ratings than men when decoding facial expressions [13]. The type of displayed smile affects also the perception of the observer. For instance, people showing amused smile are perceived more expressive, natural, outgoing, sociable,

relaxed, likable and pleasant than when they show polite smiles [11, 17]. Amused smiling faces are also perceived as being more sociable and generous than polite smiling face [19].

2.2.2 Human-machine interaction

Several researchers have explored the effect of smiling virtual characters on the user's perception both of the character's social stance and of the speech content.

Effects of smiles on social stance.

In Krumhuber, Manstead, and Kappas [15], the results show that virtual characters displaying a felt smile (longer onset and offset) were rated as more attractive, more trustworthy, and less dominant than those showing a faked smile (a short onset duration). In Rehm and André [26], a perceptive test has enabled the authors to measure the impact of fake expressions of smile on the user's subjective impression of the character. The participants were able to perceive the difference, but they were unable to explain their judgment. The character expressing an amused smile was perceived as being more reliable, trustable, convincing, credible, and more certain about what it said compared to the character expressing a negative emotion masked by a smile.

In Krumhuber, Manstead, and Kappas [15], a gender effect has been noticed: smiles shown by female virtual characters are judged less authentic that those displayed by men, whatever is the smile.

Effects of smiles on speech content.

In Krumhuber, Manstead, Cosker, Marshall, and Rosin[14], the authors have explored the impact of different types of smile displayed by virtual faces on the users' perception of the virtual character's speech content. The context of the interaction is a job interview. The results show that the type of smiles used by the virtual character has an impact on users' judgments and employment decisions: when the virtual character uses an amused smile the users perceive the job as more positive and more suitable than when the virtual character exhibits a polite smile or a neutral expression. Note that the virtual character smiles when telling an amusing utterance, *i.e.* in a situation in which the user may expect an amused smile.

Moreover, as shown in Theonas, Hobbs and Rigas [31], smiles of virtual characters, expressed in an appropriate situation, enable the creation of a sense of comfort and warmth and a global friendly and living atmosphere.

In conclusion, when displayed by a human, the amused and the polite smile may be distinguished through morphological and dynamic characteristics. Despite some specific muscle contractions associated to smile types, no consensus exists in the literature on the facial characteristics of amused and polite smiles (Section 2.1.1). In the context of virtual characters, researchers have mainly focused on amused smile to express an emotion of joy, and sometimes on polite smile (in the particular context of a fake smile) to mask an expression of sadness. In our work, we propose a method to design virtual character's smiles that are directly created by users. We then explore the effects of these expressed smiles on the user's perception of the virtual character.

Research shows that smiles expressed both by a human or a virtual character enhance the social stance perceived by others, and particularly for smiling male (be virtual or human) and for a displayed amused smile. However, existing research has mainly compared the global perception of an agent (virtual or human) expressing no smile or an amused or a polite smile. In our work, we investigate the effect of a virtual character displaying both smiles at different moment of its speech.

Before presenting the study on the effect of smiles on user's perception, we first introduce the method used to characterize the features of virtual character's amused and polite smiles.

3. THE CHARACTERISTICS OF VIRTUAL SMILES

In order to identify the morphological and dynamic characteristics of the amused and the polite smile of a virtual character, we have proposed a human-centric approach: we have created a web application that enables a user to easily create different types of smile on a virtual character's face. Through radio buttons on an interface, the user could generate any smile by choosing a combination of seven parameters (amplitude of smile, duration of the smile, mouth opening, symmetry of the lip corner, lip press, and the velocity of the onset and offset of the smile). We have considered two or three discrete values for each of these parameters (for instance, small or large for the amplitude of the smile). These parameters were selected as being pertinent in smile behaviors [22]. When the user changes the value of one of the parameters, the corresponding video of a virtual character smiling is automatically played. Considering all the possible combinations of the discrete values of the parameters, we have created 192 different videos of smiling virtual character. The user was instructed to create one animation for each type of smile. Three hundred and forty eight participants (with 195 females) with a mean age of 30 years have created smiles. We have then collected 348 descriptions for each smile (amused and polite). The experiment is presented in details in [23].

Based on this smile corpus and on a decision tree classification technique, we have defined an algorithm to determine the morphological and dynamic characteristics of the smile types that a virtual character may express. We have chosen to use decision tree learning as this technique is well-adapted to qualitative data and produces results that are interpretable and that is easily implemented in a virtual character. By applying the CART (Classification And Regression Tree) method [3], with the morphological and dynamic characteristics as input variables and the types of smile as target variables, we have obtained a decision tree in which the *nodes* correspond to the smile characteristics and the *leaves* to the smile types. In the resulting decision tree, 10 leaves are labeled as polite smiles, and 7 as amused smiles. The advantage of such a method is to consider, not only one amused or polite smile but several smile types. That enables one to increase the repertoire of the virtual character's expressions. The global error rate is 27.75%, with a 95% confidence interval of 1.2%: the global error rate is in the interval [26.55%, 28.95%] (for more details on the corpora of smiles and the proposed algorithm, see [22]).

To validate the resulting smiles, an evaluation of four of the best classified amused and polite smiles have been performed in context. Different scenarios (of polite and amused

situation) were presented in text to the user. For each scenario, video clips of virtual character's different smiles were presented. We asked users to imagine the virtual character displaying the facial expression while it was in the situation presented in the scenarios. The user had to rate each of the facial expressions on its appropriateness for each given scenario. The evaluation has been conducted on the web through a platform of tests developed using Flash technology. Seventy-five individuals participated in this evaluation (57 female) with a mean age of 32. The evaluation revealed significant results showing that the generated smiles are appropriate to their corresponding context (for more details on the experiment, see [23])

The next step is to measure the effect of these smiles on partners of an interaction. For this purpose, we have conducted a study to identify how users perceive smiling virtual characters saying a sentence, varying the gender of the virtual character and the types of smile being expressed. We present in more details this study in the next section.

4. MEASURING THE EFFECTS OF SMILING VIRTUAL CHARACTERS

In order to measure the effects of the expressions of smile by virtual characters, based on a human-centric approach, we have conducted a study to collect perception the users have of a virtual character when the later displays polite and amused smiles. We consider the situation in which the virtual character expresses smiles when speaking[1]. Given the types of smile considered, we have chosen positive situations to match the types of smile. The agent tells a joke to the user. The display of an amused smile by the virtual character is relevant in this situation. The polite smile is used to accompany the virtual character's salutation at the beginning of its talk [24, 4].

Procedure.

We performed the evaluation on the web through a platform of tests developed using Flash technology. The test has two parts. In the first part, each participant watches four videos of a virtual character telling a joke (Figure 1): two video clips of a female virtual character telling a joke and two video clips of a male virtual character telling a joke. The four jokes told to the participant were different. To try to ensure that the user watched each video clips, we imposed that the user cannot go to the next page before clicking on the play button of the video clip. The order of the video clips has been counterbalanced to avoid an effect of the order on the results. In total the duration of the test was around 20 minutes.

After watching each video clip, the user had to rate the stance of the virtual character on a Likert scale of 5-points. Stance is defined in Scherer [28] as "affective style that spontaneously develops or is strategically employed in the interaction with a person or a group of persons, coloring the interpersonal exchange in that situation (e.g. being polite, distant, cold, warm, supportive, contemptuous)". In this study, we have considered the following stances as being relevant to the scenarios: *spontaneous*, *stiff*, *cold*, *warm*, *boring*, and *enjoyable*. Moreover, to measure the effect of smiles on the perception of what the agent said, we asked the user to indicate how well she understood the joke and if she likes it.

In the second part of the test, four videos of the virtual character smiling were presented to the user. Here, the virtual character just smiles without speaking. For each video, we asked the user to indicate the types of smile displayed by the virtual character: *polite*, *amused*, *none of them* (Figure 2). In this way, we verify if the smiles are perceived by the users as expected. Once again, the order of the presented videos was counterbalanced to avoid an effect of their order on the results.

Figure 2: Screenshot of the second part of the test

Smiles.

The video clips presented to the user correspond to the smiles resulting from our algorithm and that were validated by the evaluation (Section 3). For each type, we used two different smiles with a good recognition rate. Table 1 indicates the characteristics of these smiles.

id	type	size	mouth	sym.	lip	cheek	onset	dur.
1	pol.	small	close	yes	no	no	0.4s	3s
2	pol.	small	close	no	no	no	0.4s	1.6s
3	amu.	large	open	yes	no	yes	0.8s	3s
4	amu.	large	open	yes	no	yes	0.8s	1.6s

Table 1: The characteristics of the amused (amu) and polite (pol) smiles. In the first line, *size* indicates the size of the lip extension, *mouth* indicates if the mouth is opened or closed, *sym* indicates if the smile is symmetric or not, *lip* if the lip is pressed, *cheek* if the cheek is raised, *onset* the duration of the onset and offset, and *dur* the total duration of the smile.

Virtual characters.

In order to measure the effect of gender on the user's perception of virtual character's smiles, we have considered two different virtual characters: one female, named *Poppy*, and one male, named *Obadiah*. Figure 3 illustrates the virtual characters Poppy and Obadiah smiling.

Virtual characters' talk.

[1]We do not explore the display of smile when the virtual character is listening, *i.e.* smiles used as backchannel. For instance see [2] for a study on its effect on user's perception.

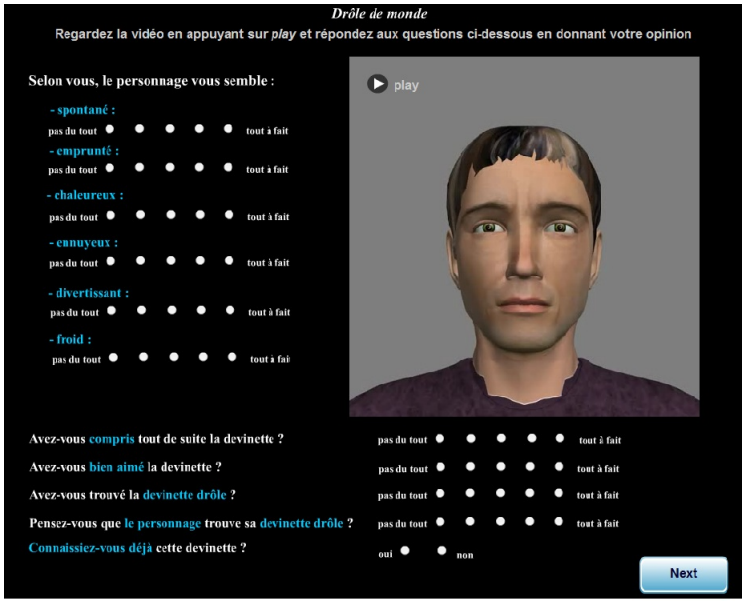

Figure 1: Screenshot of the first part of the test

Figure 3: Screenshot of the two virtual characters smiling

The virtual characters spoke French. The video clips presented to the participants correspond to the virtual characters telling a riddle to the user after a brief salutation. For instance (translated from French): "Good morning, I know a little riddle, what is the future of I yawn? I sleep! ". Four different riddles have been selected based on a brief evaluation of sixteen riddles. We have asked 7 persons (3 females and 4 males) to rate their liking of the sixteen riddles between 0 and 5. Based on the results, we have selected the riddles with the maximum rate and the minimum standard deviation. We suppose that the selected four riddles are approximatively equivalent. Finally, in terms of verbal behavior of the virtual character, only the riddle varies from one video clip to another. The beginning of the talk and the tonality of the voice do not vary.

Concerning the non-verbal behavior, only the smiles (both the type of smiles and the moment when it is expressed) differ from one video clip to another. Four conditions have been considered:

- *no smile condition*: the virtual character expresses no smile during its talk;
- *polite smile condition*: the virtual character displays only the polite smile when the virtual characters is saying "good morning";
- *amused smile condition*: the virtual character expresses only the amused smile when it says the response to the riddle;
- *both smiles condition*: the virtual character displays the polite and amused smiles at the moment described in the polite and amused conditions.

The different smiles expressed by the virtual characters are those described Table 1.

Participants.

Two hundred and forty two individuals participated in this study (158 female) with a mean age of 30 (SD = 10.35). They were recruited via mailing lists on line. The participants were mainly from France (N = 223), followed by Belgium (N = 5). There was some participants from Germany, Algeria, Tunisia, and Italy. Each participant has watched four video clips (two of Poppy and two of Obadiah telling each a different riddle)[2] and four video clips of the virtual characters just smiling (in the second part of the test).

In the next section, we present in details the results of this test.

5. USER'S PERCEPTION OF SMILING VIRTUAL CHARACTERS

5.1 Results

First of all, we have analyzed the results of the second part of the test to ensure that smiles have been perceived correctly, *i.e.* amused smiles have been tagged as amused and polite smiles as polite by the participants. Globally, the smiles have been in average categorized correctly, except one amused smile displayed by Poppy categorized in average

[2]Note that the experimental design does not correspond to repeated measures design because each participant is not exposed to all the conditions of the experiment.

more as polite than as amused smile (smile with the id 4 in Table 1). We have then decided to exclude the video clips in which Poppy displays this smile. In total, we have considered 483 video clip's rating.

To measure the effects of smiles on the user's perception, we have performed ANOVAs and the post hoc Tukey's test to evaluate the significant differences of rating between the different conditions (no smile, polite smile, amused smile and both smiles condition).

The significative results are presented in Tables 2. The first column indicates the condition compared (N for no smile, A for amused smile, P for polite smile, and AP for both smiles condition) and the first line the studied social stance. The elements of the table correspond to the condition in which the social stance of the virtual character has been the best perceived (n.s. means non significant, *: $p < .05$, **: $p < .01$, ***: $p < .001$). For instance, in Table 2, the notation A^* at the intersection of the line *N-A* and the column *Enjoyable* means that, in the amused smile condition, the virtual character has been perceived significantly more enjoyable (with $p < .05$) than in the no smile condition.

	Warm	Enjoyable	Cold	Boring
N-A	A^{***}	A^{*}	N^{*}	n.s.
N-P	P^{***}	n.s.	n.s.	n.s.
N-AP	AP^{***}	AP^{**}	N^{***}	N^{**}
P-AP	AP^{***}	AP^{*}	n.s.	n.s.

Table 2: Comparison of the user's perception of the virtual character's social stance in the different conditions

To measure the effects of gender, we have performed T-Test. The gender of the virtual characters has significant effects on the user's perception. For instance, when Poppy is smiling (whatever is the smile), she is perceived significantly less *cold* (and warmer) than Obadiah expressing the same smile (with $p < 0.05$). Poppy is perceived less *boring* with one smile (polite or amused) than Obadiah with the same smile (with $p < 0.05$). With the amused smile (with or without a polite smile), Poppy is perceived significantly more *spontaneous* and *enjoyable* than Obadiah expressing the same smile (with $p < 0,01$).

With regard to these results, we have more precisely analyzed the significant differences for each virtual character separately. Contrary to the results presented in Table 2, it appears that, compared to the expression of only the polite smile, Poppy is perceived significantly more *spontaneous*, *warm* (and less *cold*), and less *stiff* when it expresses an amused smile (with $p < 0.05$). For Obadiah, the expression of an amused smile (with or without a polite smile) enhances the warm impression of the virtual character (with $p < 0.05$).

Concerning the effect of the gender of the user on her perception, only one significant result has been noticed: women perceive the virtual character as significantly more polite when it expresses a polite smile than men. This result can be explained in the light of the research of [15] showing that women are more sensitive to non-verbal behaviors and more able to decode facial expressions cues for virtual characters' faces (Krumhuber et al., 2007), and of the research of [13] showing that women make more extreme judgment ratings than men when decoding facial expressions.

Concerning the effects of smile on the perception of the content of the sentence, significant differences appear. The users prefer the riddle and judge the riddle funnier when the virtual character expresses both smiles than with no smile or only one (polite or amused) (with $p < 0.05$). Moreover, as expected, the user judges that the virtual character thinks its riddle funnier when it expresses an amused smile (with or without a polite smile) compared to the expression of no smile or only a polite smile (with $p < 0.001$). This result confirms that the amused smile is viewed by the user as an information on the positive state of the virtual character.

We discuss in more details the results of the study in the next section.

5.2 Discussion

The results of the study confirm that smiles enhance the social stance of a virtual character. Indeed, globally, the smiles (both the polite and amused smiles) increase the warm stance of the character. Particularly, the amused smile enables to improve the perception of the virtual character in terms of enjoyment compared to no smile or a polite smile. The display of the polite and the amused smile in the same sentence enables to decrease the boring stance of the virtual character. These results are consistent with previous research showing that individuals and virtual entities who smile are perceived more positively than non-smiling agents (see Section 2.2). However, the results also highlight the impact of the different smiles on the user's perception, showing that the display of an amused smile enables one to enhance certain social stances of the virtual character (warm and enjoyment) compared to the display of a polite smile. These results can be explained as amused smile is commonly associated to felt smile reflecting a positive emotion, compared to polite smile generally associated to fake smile. These effects on the perception of the virtual character's stances confirm that the users perceive the difference between smiles, and more particularly between their associated communicative intention, when the virtual character displays them in a talk. The results show that the use of both smiles enables one to decrease the boring stance of the character. That can be due to the variability of smiles expressed by the virtual character in appropriate situation. It may reflect more engagement from the virtual character.

A gender effect was also revealed. The female virtual character displaying an amused smile is perceived more positively (spontaneous, warm, enjoyable) that the male virtual character expressing the same smile. In particular, it seems that to add an amused smile in a sentence with a polite smile enables one to decrease the stiff stance. In contrary, the male virtual character is generally perceived more boring and cold when smiling (whatever is the smile) compared to a smiling female virtual character. Whereas previous research in Human and Social Science has shown that the absence of smile for a woman deteriorates her image compared to a man (see Section 2.2), the results of our study show that the smile displays by a female virtual character enables it to enhance her image (spontaneous, warm, enjoyable) compared to a male virtual character. These results confirm the recent experiment reported in Kulms, Krämer, Gratch, and Kang [16] showing that virtual character's non-verbal behavior may be predominant on stereotype attribution.

In the next section, based on the results of the experiment,

we attempt to propose a model to automatically compute how the (potential) perception of the user of the virtual character's stance[3] evolves depending on its smiling behavior.

5.3 Toward a model of user's perception of a smiling virtual character

In order to enable a virtual character to approximate the user's perception of its social stance, we propose a first model to automatically compute the potential perception of the user depending on the smiles displayed by the virtual character when speaking. This model aims at estimating the probability that a virtual character is perceived as *spontaneous*, *stiff*, *warm*, *enjoyable* and *boring*. In the collected data on user's perception (Section 4), each stance was rated along a 5 point Likert scale, we can represent this as natural values ranging from 0 to 4. To provide convenient and intelligible variables, we map the discrete values to three categories: the value 0 is associated to *neutral*, the two lowest values (for x=1 or x=2) are associated to *low*, and the two highest values (for x=3 or x=4) are associated to *high*. The probabilities to obtain such values for each social stance are computed based on the results of the study (Section 5.1). For instance, the probability that the female virtual character is perceived highly spontaneous by displaying an amused smile when telling something positive is $P(spontaneous = high|(smile = A \vee smile = AP) \wedge gender = female) = 0.27$, *i.e.* the probability that spontaneous=3 or spontaneous=4 in the condition A (only an amused smile is expressed) or AP (an amused and polite smile are expressed). Finally, after each sentence is pronounced by a virtual character, given its gender and its smiling behavior (polite smile, amused smile, both smiles, or no smile), the model provides a matrix reflecting the probability of the user's (potential) perception of the virtual character's social stance. For instance, the matrix illustrated in Figure 4 reflects the potential social stance perceived by the user for a male virtual character which has not expressed a smile when telling something positive.

	neutral	*low*	*high*
spontaneous	0.44	**0.47**	0.09
stiff	0.14	**0.49**	0.37
warm	**0.54**	0.42	0.04
enjoyable	0.37	**0.55**	0.09
boring	0.06	0.29	**0.65**
cold	0.05	0.28	**0.67**

Figure 4: Matrix of probabilities representing the user's (potential) perception of a male virtual character that does not display an amused smile when telling a riddle.

The model enables us to measure the effects of smile but also the effect of *not* displaying a specific smile in a situation in which the user may expect this non-verbal behavior.

Thus, it is an attempt to compute how user's (potential) perception of its interactant's social stance, based on its nonverbal behavior, evolves during an interaction. The proposed approach is *human-centric* since both the signals themselves, their corresponding communicative functions, and their impacts on the perceptive social stances, have been defined by the users. The resulting model characterizing the social stances that the user attributes to the virtual character given its smiling behavior, can be viewed as a model of the user's Theory of Mind (ToM, [5]) on the social stance inferences.

Our model still needs to be extended in several directions. It has been constructed from results emanating from a specific scenario (saying riddle). We still have to see if it still hold for situations in which the virtual character does not only tell something funny (like a riddle), but something globally positive (*i.e.* reflecting a positive emotion). Similar concerns hold for the perception of polite smile. We need to validate if we can extend our model to any situation for which the expression or non-expression of a polite smile is expected. Greeting is such a situation but there are others as those described in Ochs, Niewiadomski, Brunet, and Pelachaud [23]. Moreover we suppose that the computed probabilities are cumulative during the interaction. For instance, several successive sentences reflecting a positive emotion without displaying an amused smile will lead to successive decreasing of the user's perception of the virtual character's positive social stance. This hypothesis has to be validated during virtual character-user interaction.

6. CONCLUSION

In conclusion, in this paper, we have performed a study to measure the effects of virtual characters displaying polite and amused smiles when saying a sentence, on the user's perception of the virtual character's social stance. The results of the study have revealed significant differences, confirming that smiles enhance the social stance of a virtual character. These results are consistent with previous research showing that individuals and virtual entities who smile are perceived more positively than non-smiling agents (Section 2.2). Moreover, the results also highlight the impact of the different smiles on the user's perception, showing that the display of an amused smile enables one to enhance certain social stances of the virtual character (warm and enjoyment) compared to the display of a polite smile. In our experiment we have considered the expression by a virtual character of both polite and amused smiles when speaking. Previous research has mainly studied the effects of these smiles separately whereas in communication both smiles are generally expressed.

Our results also provide new insights concerning the gender effect on the user's perception. Indeed, contrary to human-human interaction, a smiling female virtual character seems to be better perceived than a smiling male virtual character.

Based on the measures collected during the study (Section 5.1), a probabilistic model of the user's (potential) perception of a smiling virtual character has been proposed. It enables one to evaluate the user's perception of virtual character's social stance during the interaction given the virtual character's gender and its smiling behavior. Both the effect of the expression of smile in appropriate situations and the absence of smile in expected smiling situations have been modeled.

The next step consists in evaluating such a model during an interaction with users. For this purpose, we aim

[3]We do not model the user's perception of the virtual character's speech content since our results are closely linked to the specific context of the talk.

at integrating our model in the platform SEMAINE [29] to test at several moments during the interaction if the proposed model provides an adequate virtual character's image of what users have.

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