From emotions to interpersonal stances: Multi-levels analysis of smiling virtual characters

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***Abstract*—In this paper, we explore the emotions and interpersonal stances that the expressions of smile may convey by analyzing the user's perception of smiling embodied conversational agents at different levels: (1) a *signal level* considering the emotions and stances that a signal of smile may convey depending on its morphological and dynamic characteristics, (2) a *communicative level* by exploring the effects of the ECA's smiling behavior on the stances perceived by a user, and (3) an *interactive* level by showing the influence of the alignment of smiles in a dyad of virtual characters on the perceived stances. In the light of this multi-level analysis of smiles, we propose the architecture of a fully interactive smiling ECA based on an extension of the SAIBA framework.**

I. Introduction

Nowadays, computers are more and more used to endow roles typically embodied by humans, such as tutor in virtual learning class or assistant for virtual task realization. Such roles are often embodied by animated cartoon or human like virtual characters, called *Embodied Conversational Agent* (ECA) [1], able to communicate through verbal and non-verbal behavior with the user. Several studies have demonstrated that when people are involved in an interaction with such virtual characters, they tend to react naturally and socially as they would do with another person [2].

One important social cue during social interactions is *smile* [3]. A smile may convey different meanings depending on subtle characteristics of the facial expression. For instance, a smile may communicate *emotions* such as amusement or embarrassment but also *stances* such as politeness or humorous, depending on which facial muscles are activated. People consciously or unconsciously display these different smiles during an interaction and are able to distinguish them when they are expressed by their interlocutor [4]. Moreover, the social signal of smiles is "profoundly influential" [3]. The expression of smile may have a strong impact on how the smiling person is perceived. In particular, the *smiling behavior*, *i.e.* when and which types of smiles are expressed during an interaction, may determine the perceived *interpersonal stances* [5], [6], [7], [8], [9]. The *interpersonal stance* corresponds to an attitude, spontaneously or strategically expressed, that conveys the relationship of a person to the interlocutor (for example"warm" or "polite") [10], [11]. Moreover, during an interaction,"stances are constructed across turns rather than being the product of a single turn" [12]. When the stances of each partner of the interaction are put in presence, *dyadic stances* can be inferred from diachronic alignment between interactants. For instance, the alignment of the non-verbal behavior of the speaker and of the listener may convey stances of mutual interest and pleasantness [13]. Finally, the effect of a smiling behavior might vary from positive to negative depending on its type, when it is expressed, and in response to what.

In this paper, we explore the emotions and interpersonal stances that the expressions of smiles may convey by analyzing the user's perception of smiling embodied conversational agents at different *levels*:

- at a *signal level*, we highlight the relation between the morphological and dynamic characteristics of a smiling virtual face and the perceived emotions and stances (Section 2);
- at a *communicative level*, we present studies showing the effects of different ECAs' smiling behaviors on the stances perceived by a user interacting with the ECA (Section 3);
- at an *interactive level*, we present the results of a recent perceptive study showing the impact of the alignment of smiles in a dyad of virtual characters on the perceived stances (Section 4).

We conclude by presenting how the results of the different levels of analysis of smiles could be integrated in an ECA (Section 5).

II. Emotions and stances expressed by virtual smiling faces

Virtual smiling faces, without any consideration of a particular context, may convey emotions and stances. A (genuine) smile is characterized by the activation of the zygomatic major muscles, on either side of the face. However, other muscles may be involved in an expression of smile. Depending on the activated muscles and how they are activated, different types of smile with different meanings can be distinguished [14]. Ekman [14] identified 18 types of smile and proposed that there might be as many as 50 altogether. The most common type of smile is the *amused smile* (also called felt or Duchenne smile). Another type, which is often thought of as the opposite of the amused smile is the *polite smile* (also called non-Duchenne, false, social smile). A specific smile appears to express negative emotions, such as in the facial expression of embarrassment [14], anxiety [15], or frustration [16].

In the domain of embodied conversational agents, several existing virtual agents *smile* during an interaction, mainly to express a positive emotion or a positive mood [17]. Only few researchers have considered different virtual agent's smiles in order to increase the repertoire of agent's facial expressions. In [18], two different types of smile, *amused* and *polite*, are displayed by an embodied conversational agent. 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 agent to mask sadness with a smile. The characteristics of the smiles are based on the theoretical descriptions of smiles proposed in [19]. Similarly, in [20] and [21], algorithms, based on the description of Ekman [19], are proposed to generate different expressions of joy: a felt and a fake one. In these works, the polite smile is mainly considered as a particular smile masking a negative emotion.

Based on a user-perceptive approach using a crowd-sourcing method, we have developed a method to identify the morphological and dynamic characteristics of different smile types [22]. This methods breaks with the traditional approach used to create repertoire of facial expressions: instead of asking users to label predefined facial expressions, users are at the heart of the creation process of facial expressions. A web application enables a user to easily create different types of smile (amused, embarrassed and polite) on a virtual character's face by manipulating radio buttons on an interface to change the parameters of the smiles (such as the amplitude of smile, the mouth opening, the lip press, or the cheek raising). This method has allowed us to characterize the morphology of the polite, amused and embarrassed smiles. The resulting smiles have been validated as the most appropriate smile expressions in scenarios of amusement, politeness and embarrassment [22].

These studies on the signal of smile shows that the characteristics of the signal may convey particular ECA's emotions or stances, such as amusement, embarrassment, or politeness. However, the *smiling behavior*, *i.e.* when and which types of smile are expressed during an interaction, may also have a strong impact on the perceived *stances*. In the next section, we present studies showing the impact of smiling virtual character involved in an interaction with the user.

III. User's perception of stances during an interaction with a smiling ECA

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 [5], [6], [7], [8], [9]. Moreover, both the gender and the types of expressed smile may influence the perceived interpersonal stances. In Western society, women smile more than men and are also expected to do so [5], [23]. Concerning the effects of different smile types, research has shown that the type of displayed smile affects the perception of the observer. For instance, people showing amused smile are perceived as more expressive, natural, outgoing, sociable, relaxed, likable, and pleasant than when they show polite smiles [4], [23]. Amused smiling faces are also perceived as being more sociable and generous than polite smiling faces [24].

In the domain of ECAs, some studies have explored the effects of the expressions of smile on the user's perception during an interaction. In [25], a study has been performed to compare more particularly the effects of the display of an amused or polite smile on the perceived stances. The results show that virtual faces displaying an amused smile were rated as more attractive, more trustworthy, and less dominant than those showing a polite smile [25]. In [20], a perceptive test has enabled the authors to measure the impact of the expressions of polite smile on the user's subjective impression of an ECA. The participants were able to perceive the difference, but they were unable to explain their judgment. These results are in line with the recent work of [26] showing that users do not consciously notice the ECA's smiles even if the virtual smiles have a significant effect on the users. In [20], the virtual agent expressing an amused smile was perceived as being more reliable, trustworthy, convincing, credible, and more certain about what it said compared to the agent expressing a negative emotion masked by a smile (corresponding to a polite smile). As shown in [27], smiles of virtual agents, expressed in an appropriate situation, enable the creation of a sense of comfort and warmth, and a global friendly and lively atmosphere. In [26], the authors have shown that the ECA's smiles elicit users' smiles.

In [28], we describe a perceptive study we have performed on the effects of virtual characters displaying both polite and amused smiles on user's perception. The results show that the display of an amused smile enables enhancing certain social stances of the virtual character (warm and enjoyment) compared to the display of a polite smile. Moreover, in this study, 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. Based on this study, we have developed a computational model to automatically infer the potentially user's perceived stances depending on the gender of the virtual character and on its smiling behavior [28]. The model computes probabilities of the perceived virtual character's interpersonal stances depending if the virtual character expresses or not an amused or a polite smile in a potentially expected situation. The probabilities that the agent is perceived with a warm, enjoyable, boring, cold, stiff or spontaneous stances by the user are computed based on the collected corpus of users' ratings of the perceptive study [28].

One main limit of the works presented above is that they do not consider the smiles expressed by the user to display the smiles of the ECA. The smiles are generally selected based on the communicative intentions of the ECA. For instance, if the ECA has the intention to communicate happiness, an amused smile would be displayed. Some researches, such as in [29], have particularly studied the smiling behavior that an ECA should adopt when it is listening to user. Smiles are displayed by the ECA during the user's speaking turn to express understanding and liking and to facilitate the user's speech. The user's smiles, automatically detected, are also mimicked by the agent [29]. The results of the perceptive study of such a smiling listener ECA have shown the positive impact on the ECA's perceived stances. These models of smiles used as backchannels enable the virtual agent to adapt to its interlocutor, but do not take into account the reciprocal adaptation of this interlocutor. To build this reciprocity, one can propose that the ECA adapts its smiling behavior to the user's smiles not only when it listens but also when it speaks. If that perfectly makes sense, that is not enough: behaviors are computed in *reaction to* partner's behavior, but not in *interaction with* partner's behavior; the dynamical coupling associated to the mutual engagement of interactants is not modeled, and critical parameters of interaction such as synchrony and alignment which appear as side effects of this coupling [30], [31], are missed. In [32], we have shown that the agents' reactions must be reciprocal but also built "on the fly", i.e. updated by the continuously incoming reactions of the partner. We have shown that virtual agent's backchannels (one way reactions) are less effective than reciprocal reactivity to convey mutual understanding, attention, agreement, interest and pleasantness. These results are consistent with the fact that it's not only the expression of particular signal that conveys stances but also the alignment of the signal expressed by both interactants [12].

In the next section, we present a study exploring the effects of dynamical and reciprocal reinforcement of smiles on the user's perception of the ECA's stances.

IV. Dyadic interpersonal stances

To give the capability to an ECA to *align* its smile expressions with its interlocutor, the ECA should be able to *dynamically* adapt its smiles to those of its interlocutor. For instance, when the ECA is smiling, and if its interlocutor smiles back, the ECA should *reinforce* its smile to convey, stances of mutual interest and pleasantness for example [33]. In other words, the ECA should be able to modulate its own smiles depending directly on its perception of its partner's smiles.

To simulate the reinforcement of a smile, we have based our work on the characteristics of virtual virtual we have identified in our previous research work (Section 2, [22]). The following morphological characteristics of the polite and amused smiles are considered: the size of the smile (i.e. the amplitude of the zygomatics, the Action Unit 12 in the Facial Action Coding Scheme [34]), the cheek raising (Action Unit 6) and the opening of the mouth (Action Unit 25). Then, a smile reinforcement corresponds to the increase of the amplitude and duration of these characteristics (Figure 1).

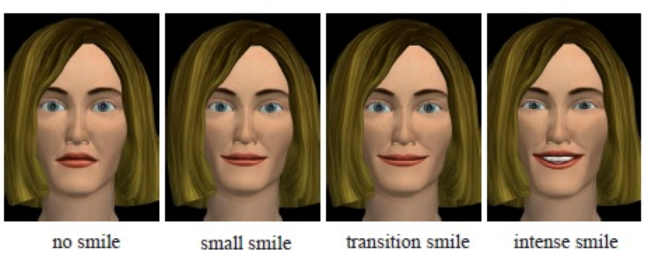

Fig. 1. Smile reinforcement

To give the capability of an ECA to reinforce dynamically its smiles during an interaction, we have developed a computational model based on a Neural Network interfaced with the SEMAINE platform [35]. The Neural Network simulator enables designing the architecture neuron by neuron and to controlling architecture dynamics in real-time (here frame by frame). The agent platform computes the communicative intention of the virtual character depending on its speech,

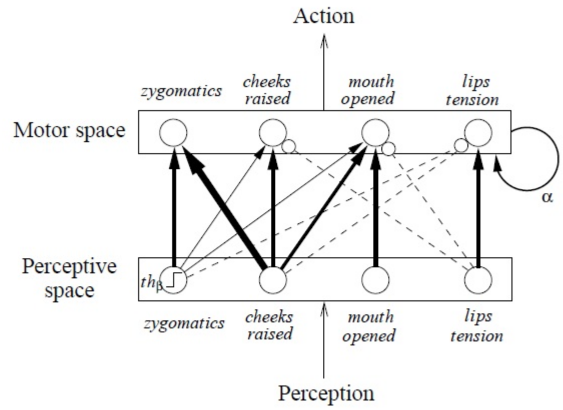

Fig. 2. Perceptive Space and Motor Space mapping: perceptions of zygomatics contraction, of raised cheeks, of opened mouth and of lips tension directly influence the motor productions of the agent's behavior.

and directly influences its actions accordingly (Figure 2). The computational model is described in more details in [32].

Perceptive study of smiles reinforcement. In order to evaluate the effect of the smiles reinforcement of an ECA on the user's perception, we have performed a perceptive study. Our objective through this evaluation is to show that the smiles reinforcement of the ECA enhances its perceived interpersonal stances. In line with our previous work on the perception of smiling ECA [28] (Section 3), we have focused on the following interpersonal stances: embarrassed (stiff), warm, boring, spontaneous, cold, and enjoyable.

Hypothesis. The hypothesis we want to validate through the evaluation is the following: *the perceived interpersonal stance is significantly enhanced when the ECA reinforces its smiles according to its interlocutor's smiles.* More precisely, the evaluation aims to show that the reinforcement of the ECA's smiles increases the impression of a warm, spontaneous, and enjoyable stance compared to an interaction in which the ECA smiles but does not reinforce its smiles with the smiles of its interlocutor.

Procedure. In order to verify this hypothesis, we have performed an evaluation. The evaluation was in French and set on the web. To be able to compare the results of this experiment with our previous perceptive study on smiling ECA [28], we have replicated some elements of the procedure, but we introduced an interactive part. In our previous perceptive study [28], users watched videos of ECAs telling a riddle. The ECA expresses a polite smile at the beginning of its talk and an amused one during the riddle. The ECA looked toward the user. In our new study, the ECA talks to another ECA. Four video clips showing two ECAs discussing with each other were presented to participants (Figure 3). For each video clip, we asked the participants to indicate their impression of the ECA without glasses on the right (playing the role of the speaker, Figure 3). The question was: "What do you think about the virtual character without glasses (on the right). According to you, it seems: embarrassed, warm, boring, spontaneous, cold, and enjoyable" (translated from French). A 5 points Likert scale (from "strongly disagree" to "strongly agree") was set for each interpersonal stance.

Fig. 3. Screen shot of a video clip of the two ECAs interacting

Video Clips. To evaluate the perception of the ECA with and without the reinforcement of smiles, we have recorded the interaction of ECAs under two conditions:

- *smiles reinforcement condition*: both the speaker and the listener mutually reinforce their smiles depending on the smiles expressed by each other. The smile of the ECA speaker (on the right) is mimicked by the ECA listener (on the left) which in turn reinforces the smiles of the ECA speaker (on the right).
- *control condition*: only the ECA listener mimics the ECA speaker's expressed smiles. That is, the ECA speaker (on the right) does not reinforce its smile.

In the video clips, the ECA speaker (on the right) tells something to the ECA listener (on the left) using an unintelligible verbal language (corresponding to an acoustic deformation of French texts). This way, we avoid the influence of what the ECA says on the user's perception. We have considered 6 different texts corresponding to the different riddles the ECA told in our previous perceptive study described in [28]. The ECA expresses a polite smile when starting speaking and an amused smile in the middle of the text. The morphological and dynamic characteristics of these smiles correspond to those identified in our previous research work [22](Section 2). For each text, we have recorded video clips in the 2 conditions described above with an ECA saying this text with an acoustic deformation and another ECA, facing it, listening. Note that in both conditions the ECA speaker is smiling (at the beginning with a polite smile and at the middle with an amused smile). However, in the smiles reinforcement condition, when the ECA listener smiles back in reaction to the ECA speaker's smiles, the latter reinforces its smiles (the polite and amused smiles) by increasing the amplitude of its smiles' characteristics and their duration. Then, the ECA listener reinforce its smiles in reaction.

The two ECAs are female to avoid a possible gender effect on the user's perception. In total, 12 video clips have been recorded. In order to visualize clearly the faces of both ECAs while keeping the impression that the ECAs are face to face, we have used a film-making technique called split-screen (Figure 3). Before starting the evaluation on the web, to ensure that the instruction, the questions, and the video clips are understandable, the platform of test has been pre-tested with 7 participants.

Participants. Sixty-six individuals have participated to this evaluation on the web (34 females) with a mean age of 34 (SD=13). They were recruited via French mailing lists on line. The participants were predominantly from France (N=63). Each participant has seen and rated 4 video clips (two video clips selected randomly for each of the 2 conditions). The order of the presented video clips was counterbalanced to avoid any effect on the results.

Results. We have collected 264 video clips' ratings. The results are illustrated in Figure 4. Independent t-Test was conducted to compare the participants' ratings of the video clips in each condition. The analysis revealed important statically significant effects of the condition on the participants' ratings of the embarrassed ($p < 0.0001$), warm ($p < 0.0001$), boring ($p < 0.0001$), spontaneous ($p < 0.0001$), cold ($p < 0.0001$) and enjoyable ($p < 0.0001$) stances (Figure 4). The ECA is perceived significantly warmer, more spontaneous and enjoyable, and less boring, cold and embarrassed when it reinforces its smiles according to the ECA listener's smiles (smile reinforcement condition) than when it does not reinforce its smiles (control condition).

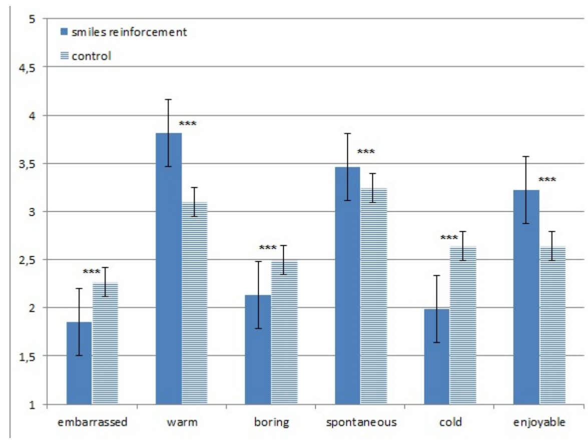

Fig. 4. Means and standard errors of the ratings on ECA's stances for the two conditions. The significant differences between the conditions are indicated by *** for ($p < 0.0001$)

Discussion. The results of this study show that the smiles reinforcement of the ECA speaker enhances its perceived stances. When the ECA smiles, but is not influenced positively by its interlocutor smiles (control condition without smile reinforcement), the ECA is perceived less positively (less warm, spontaneous and enjoyable) and more negatively (more boring, colder and more embarrassed) than when the ECA reinforces its smiles (smile reinforcement condition). These results confirm our hypothesis: *the perceived interpersonal stance is significantly enhanced when the ECA reinforces its smiles according to its interlocutor's smiles.*

In this study, we suppose that the enhancement of the perceived ECA's stances is due to the smiles reinforcement of the ECA speaker in reaction to the smiles expressed by the ECA listener. However, the smile reinforcement leads to the expression of smile with higher amplitude and longer duration. The rated perception of the participants may come from either the perception of an alignment of the speaker's smiles on the listener's smiles or from the perception of a speaker expressing smiles with higher amplitude and longer duration. Since previous studies tend to show that the user does not consciously notice the ECAs expressing smiles [26], [20], it remains difficult to identify the exact cause of the participants' perception of stances.

Given the procedure of the perceptive study, the participants were not involved in an interaction with the ECA. They remained passive as a spectator of an interaction between ECAs. The perceived stances could be different if the user is engaged in an interaction in which the ECA reinforces its smiles in reaction to the user's detected smiles. In the next section, we propose a way to integrate this result in a computational model of a fully interactive agent and to evaluate it in human-machine interaction.

V. Toward a multi-level model of a smiling ECA

The different studies presented in the previous sections highlight the various emotions and stances that smiles may convey. In this section, we propose to increase the SAIBA architecture (an international common multimodal behavior generation framework [36]) to create smiling ECAs integrating the different levels of smiles analysis (Figure 5): the *signal*, *communicative* and *interactive* levels.

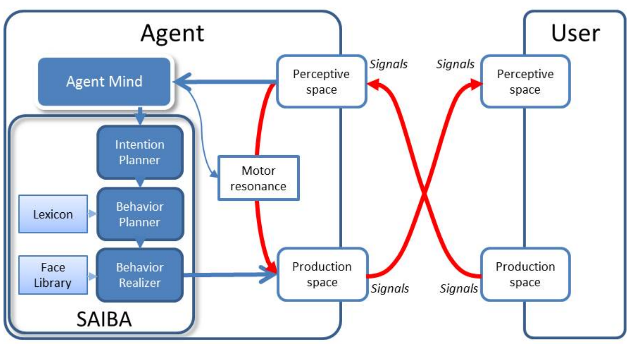

Fig. 5. Architecture of a smiling ECA

At the *signal level*, given that the signal of smile conveys different emotions and stances by itself (Section 2), for the ECA, the expression of a smile may enable it to convey or reinforce a particular message to the user. For instance, a smile of amusement communicates to the user information on the emotional state of the virtual agent (represented in the *Agent mind*, Figure 5). Consequently, the ECA may select the appropriate signal of smile to display depending on its communicative intention. For instance, if the virtual agent has the intention to show embarrassment, the face of the ECA should be animated to be perceived by the user as an embarrassed smile. To link communicative intentions to smiles, we have integrated smiles of amusement, politeness an embarrassment in Greta, an ECA based on SAIBA architecture). We have extended the *lexicon* (Figure 5) by relating communicative intentions to signals of smiles depending on their meanings, and we have described in the *facelibrary* (Figure 5) the morphological and dynamic characteristics of these smile signals [28].

At the *communicative level*, the type of expressed smiles as well as the situation in which the smiles are expressed influence the user's perception of the ECA's stances (Section 3). The ECA may then select its smiling behavior (*i.e.* when to express which smile) depending on the stances it wants to convey to the user. For this purpose, a model to automatically compute the potential perception of a user resulting from an ECA's smiling behavior is required. We have proposed such a model in [28]. The latter computes the probability that the ECA is perceived as warm, stiff, boring, enjoyable, or spontaneous depending if the ECA's communicative intention is expressed with a smile (polite or amused) (Section 3, [28]). Part of the *Agent Mind* module (Figure 5), this model enables the agent to select the smiles to express depending on the stances it wants to convey.

At the *interactive level*, the reinforcement of the ECA's smiles may impact the perception of the ECA's stances (Section 4). During a user-ECA interaction, the recent work of [26] shows that user smiles back to ECA's smiles. The ECA may decide to reinforce dynamically its smiles according to the recognized smiles of the user to convey specific stances. To give the capability to the ECA to reinforce its smiles, the SAIBA architecture is increased with the *Motor resonance* module, the *Perceptive space*, and the *Production space* (Figure 5). The *Perceptive space* (introduced Section 4) takes as inputs the characteristics of the user's detected smiles (for instance the openness of the mouth). Existing systems, such as [37], may be used to detect these smiles' characteristics. The *Motor resonance* computes the impact of the perceived smile's characteristics on the ECA's smiles production. The *Motor resonance* considers the stances that the ECA wants to convey (defined in the *Agent mind*) to determine if a smile reinforcement should be simulated. To simulate the smile reinforcement, the animation resulting from the *Behavior Realizer* module (i.e. the Facial Action Parameters - FAPS [38]) is directly modified by the *Production space* module [32]. Moreover, the *Agent mind* module considers the output of the *Perceptive space* to update its beliefs on the stances expressed by the user. Indeed, the user's smiles reinforcement in reaction to the ECA's smile expressions may be a cue on the user's positive stance toward the ECA. Note that the interpretation of the signal expressed by the user (for instance the interpretation of a signal as a smile) is part of the *Agent mind* module since the ECA's perception may depend on its emotional state (for instance a negative emotional state may decrease the probabilities to perceive positive expression) [39].

Ongoing and future works. We are integrating the module developed in [37] in the ECA Greta [40] to detect automatically the user's smiles characteristics. In order to give the capability to the ECA to reason on the effects of its smiles reinforcement on the user's perception, we aim at extending our previous model [28] that automatically computes the probabilities of the potential user's perception of the ECA's stances depending on its smiling behavior. To compute the potential resulting perception of the user in front of an ECA that reinforces its smiles, the probability of the model will be based on the values of the users' ratings of our study (Section 4), instead of considering the corpus of ratings in which the smiles reinforcement is not considered [28]. This way, this model will be used to determine if the ECA should reinforce its smiles depending on the stances it wants to convey to the user. Such a model, based on a study in which the user is not involved in the interaction (Section

4), will have to be validated. For this purpose, we aim at asking to users to interact with an ECA that reinforces its smiles in reaction to the user's detected smiles. The users' perception of the ECA's stances will be collected through a questionnaire at the end of the interaction. A comparison between the users' responses to the questionnaire and the outputs of the proposed model will enable us to validate this model. Finally, to develop entirely the proposed architecture of the smiling ECA (Figure 5), we aim at developing a model to infer the user's stances toward the ECA from his detected and interpreted smiling behavior. Moreover, the architecture we have presented can be extended to other behaviors than smiles, involved in alignment such as head movements [13].

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