Towards a smiling ECA:
Studies on mimicry, timing and types of smiles

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ABSTRACT

Smile is one of the most often used nonverbal signals. Depending on *when*, *how* and *where* it is displayed, it may convey various meanings. We believe that introducing the variety of smiles may improve the communicative skills of embodied conversational agents. In this paper we present on-going research on the role of smile in embodied conversational agents. In particular, we analyze the significance of smiling while the agent is either speaking or listening. We also show how it may communicate different messages such as amusement, embarrassment and politeness through different smile morphologies and dynamism.

Categories and Subject Descriptors

H.5.2.f [**Information Technology and Systems**]: Information Interfaces and Representation (HCI) User Interfaces-Graphical user interfaces; H.5.1.b [**Information Technology and Systems**]: Information Interfaces and Representation (HCI)Multimedia Information SystemsArtificial, augmented, and virtual realities

Keywords

smile, virtual agents, ECA, facial expressions, social interaction, synchrony

1. INTRODUCTION: WHY AN ECA SHOULD SMILE?

Smiling is one of the simplest and most easily recognized facial expressions [12]. Only one muscle, the zygomatic major, has to be activated to create a smile. Even if a smile is most often associated with an expression of a positive emotional state (e.g. [11]) it may convey different meanings – such as embarrassment [20] or politeness [1]. Perceptual studies have shown that people unconsciously and consciously distinguish between a smile of enjoyment and a social smile (also called fake) [13]. According to Fridlund [14] these smiles are different signals that have different meanings. Different types of smiles occur in affect displays (e.g. enjoyment [11], embarrassment [20] or anxiety[16]) but smiles may communicate many other social messages.

Moreover, the research has shown that a smiling human is perceived as more expressive, outgoing, relaxed, sociable, generous, trustworthy, warmer, attractive, intelligent, polite (cited in [27]). People who smile often are perceived more positively than people who smile less: they are seen as more attractive, friendly, warm and honest [37]. Smiling people are also judged more leniently than non-smiling ones [23].

The smiling behavior depends also on the social context of the interaction, such as the presence of friends [19] or the gender of the participants [26]. Deutsch [7] demonstrated that smiling is related to the status of a person. A low power subjects smile more often than a high power ones [7]. Moreover, high power people more often display the smile of amusement while low power ones rather display social smiles during the interaction with high-power individuals [24].

Last but not least, by smiling during the conversation, people provide important information about the human-human interaction. For example, they show the intention to start an interaction [10]. Smiles, as other facial expressions, have several special functions, like helping to regulate the flow of the conversation [9]. By smiling to the speaker, listeners can encourage him to go on with the conversation [33] or they provide backchannel signals [5] showing, for instance, their appreciation towards what the speaker is saying [4]. Indeed, smile is one of the most frequent and studied listener's facial displays. In [5] Brunner conducted several tests to understand the role of smiles produced by

a listener during a conversation. He saw that placement of smiles in conversations is very similar to that of other typical backchannel signals like paraverbals and head nods, so smiles can be considered as backchannels.

Recapitulating, a smile, when displayed by humans, may have various meanings. Thus, it is not surprising that smiling as a communicative signal is often used in embodied conversational agents (ECAs). An ECA can express a smile to show pleasure, to show friendliness to other people or to replace a word such as "hello" [31]. The recent works show that a smiling agent is perceived as more convincing, credible, attractive, trustworthy (cited in [22]). It enhances the human-machine interaction, for instance the perception of the task, of the agent, and the motivation and enthusiasm of the user [21, 40]. However, an inappropriate smile (an inappropriate type of smile or a smile expressed in an inappropriate situation) may have negative effects on the interaction [40].

People distinguish between different types of smiles (e.g. smile of amusement, fake smile, masking smile) displayed by an agent [36, 29]. Various smile expressions were used by some agents to express social relations (i.e. social distance and power) [29] and empathy [28]. Depending on the smile type the same agent was perceived more or less credible and trustworthy [36]. Consequently, we argue that a *smiling embodied conversational agent* (SECA) should use smiles not only to communicate its positive emotions but to convey also other meanings. It may smile differently depending on its emotional state, social context and behavior of its human interlocutor. In this paper we present the results of three preliminary studies carried out to build a SECA. In the following section we present the experiment aiming at analyzing the role of smiles as a listener behaviors. In section 3 we describe a dyad of SECAs which synchronize their smiles according to the quality of their interaction. In section 4 we describe another experiment that allowed us to discover different polite, embarrassed and amused smile patterns to be displayed by agent. We conclude in section 4.

2. POSITIVE EFFECT OF BACKCHANNEL SMILES

This first evaluation aims at discovering if a smiling behavior performed by an embodied conversational agent is perceived in a similar positive way by human interactant and if interacting with an agent who smiles back is more satisfying and pleasant. In particular, we are interested in the mimicry of the smiling behavior as a form of backchannel. Several studies have shown that mimicry has positive effects on the successfulness of the conversation that is perceived as more pleasant [41]. Mimicry increases empathy, liking, and rapport, binding people together [6]. Moreover, the speaker's feeling of engagement increased when listeners provide backchannel signals such as mimicry of the speaker's behavior (e.g. [39]). In the following study we check if all these positive effects of mimicry behavior are presented also during user - agent interactions.

2.1 Evaluation study

Subjects interact with an agent in three conditions: (**MS**) the agent provides backchannel signals and smiles only to mimic the participant when she smiles; (**RS**) the agent provides backchannel signals smiling randomly, independently of the participant's smile; (**NS**) the agent provides backchannel signals without smiling at all.
We hypothesize that:

- *hp1*: subjects feel more engaged in condition MS than in conditions RS and NS; and in condition RS than in NS.

- *hp2*: the interaction is seen as easier and more satisfying in condition MS than in conditions RS and NS; and in condition RS than in NS.

- *hp3*: the agent is rated more agreeable, positive, warm, sincere and involved when it smiles during the interaction.

- *hp4*: participants smile more in conditions MS and RS than in NS.

- *hp5*: participants smile longer in conditions MS and RS than in NS.

2.2 Method and participants

During the experiment participants sat in front of the ECA displayed on a PC screen. Two video cameras recorded both the user's and the agent's behavior. Later on, videos were treated and synchronized to analyze the human-agent interaction. Twelve French speaking subjects (42% women, 58% men). On average, male participants were 30.4 years old, whereas female subjects were 34.8. Subjects were asked to read three short comic cartoon-strips (one at a time) and then tell the agent all that they remembered about the story, the characters and the drawings. They had to tell a story in each condition described above. There was no time limit for the task. After having told a story, subjects had to fill in a questionnaire (derived from that used by Gratch et al. in [15]) to evaluate the agent's listening behavior during the interaction. Participants could rate each statement of the questionnaire on an 8-point Likert scale (1 = disagree strongly; 8 = agree strongly).

During the interaction the agent provides only positive backchannel signals to show it is listening and to incite the participant to go on. Possible backchannels are: raise of the eyebrows, head nod, smile and all their combinations [3, 18]. To generate backchannels signals according to the user's non-verbal behavior, our system needs reliable video and audio information. Since we do not have at disposition a reliable and robust application a Wizard of Oz setting is used. In another room the experimenter drove the system to provide signals of smile. The experimenter provided a backchannel each time a pause in the user's voice occurred, or when a pitch change was perceived (like at the end of an exclamation or a question) or when the user was smiling (any type of smiles was considered). Backchannels containing a smile were selected to mimic user's smiles in the MS condition or to provide random smiles in the RS condition.

2.3 Results

All participants (N=12) gave responses to the statements in each condition. The Friedman-test was used for this repeated-measures design. Results show that there is an effect of the condition only for three statements: "warm" ($\chi^2 = 6.5$, $df = 2$, $p = 0.039$), "positive" ($\chi^2 = 6.5$, $df = 2$, $p = 0.039$) and "I think that the agent wasn't really listening to me" ($\chi^2 = 6.07$, $df = 2$, $p = 0.048$). We used the Wilcoxon to compare pair-wise the answer to each question. The Wilcoxon test showed significant differences for some of the questions. Subjects felt less engaged in condition NS

than in condition MS ($p < 0.05$). They judged the agent less positive ($p < 0.05$) and less warm ($p < 0.05$) in condition NS than in condition RS. A difference appears also between conditions NS and MS ($p < 0.05$). The agent appeared more interested in the condition RS, where it smiles without mimicry, than in condition NS ($p < 0.05$). The interaction has been judged more frustrating in condition NS than in MS ($p < 0.05$). Finally, participants felt more at ease ($p < 0.05$) and more listened to ($p < 0.05$) while telling the story to the agent in condition MS than RS. These results sustain our first three hypotheses.

All the smiles performed by both the agent and the user were annotated in the three conditions. We calculate the frequency of the user's smiles as the total number of smiles divided by the duration of the interaction in seconds. The reliability of annotation for the frequency of smiles was assessed for 17% (6 videos, 2 per condition) of the data, realized by a second coder who was FACS (Facial Action Coding System) certified. Agreement was assessed with Cohen's kappa, the mean kappa across conditions was 0.93. The mean frequency of smiles per second is 0.06 in condition MS (sd 0.042), 0.042 in RS (sd 0.034) and 0.028 in NS (sd 0.029). Wilcoxon test showed a difference between the conditions MS and NS ($p < 0.05$). The difference between the conditions RS and NS was on the limit of significance ($p = 0.052$). No significant difference was found between the conditions MS and RS ($p = 0.117$).

We also calculated the mean duration of smiles as the total duration of smiles divided by the number of smiles. The mean duration of smiles per second is 1.58 in condition MS (sd 0.966), 1.42 in RS (sd 0.509) and 0.89 in NS (sd 0.735). We applied the Wilcoxon test and we looked at (1-tailed) Exact sign. We obtained a significant difference between the conditions RS and NS ($p < 0.05$) and the conditions MS and NS ($p < 0.05$). No significant difference was found between the conditions MS and RS ($p > 0.05$). That sustains our fifth hypothesis.

2.4 Discussion

Results showed that there was a clear increase in the positivity of the rating when the agent smiled. However, we did not find a significant difference between the rating of an agent that shows random smile backchannels and one that shows mimicked smile backchannels. These non-significant results may be explained by two facts. The first one is that the effect could be stronger, for example, with an increase of the duration of the interactions, as our interaction time was on average not longer than 2 minutes. The second fact is that in MS condition the agent's smiling behavior depends entirely on the user's smiles: if the user does not smile at all, thus neither does the agent. By contrast, in RS condition, the agent gives backchannel smiles with a fixed probability, independently from the (no-)smiling behavior of users.

To improve the interaction and the users' perception of the ECA, mimicking user's smiles is not enough, the agent should also emit smiles of its own will. To be able to compare MS and RS conditions, the agent should emit always the same quantity of smile (i.e. 2 smiles every minute of interaction) and vary just when they are displayed (when the user does not smile much, the ECA gives backchannels smiles with a fixed probability, and when the user smiles, the ECA imitates her/him).

Through our test we saw that participants smile longer

and more often when the agent smiles. The observation of the videos allowed us to gather some interesting information: We noticed that in both smiling conditions (MS and RS) users tend to mimic the agent's smile and when they did not respond to the smile usually they were not looking at the agent. However we did not obtain significant statistic results to prove such a finding.

In conclusion, our test shows both that the agent's smiling behavior has an impact on the user's perception of the agent, and that mimicry behavior does not necessarily benefit to the interaction because it very depends on the user's behavior. The agent's backchannel smiling behavior, random and mimicked, should be taken into account in ECAs design since it appears to influence the quality, easiness and warmth, of the user-agent interaction.

3. SHARED UNDERSTANDING, SYNCHRONOUS SMILES

When two agents smile within the same temporal window, we refer to synchronous smiles. As synchronous non-verbal behavior in general, synchronous smiles are indices of the quality of interaction within a dyad: friendship, affiliation and mutual satisfaction of expectations [8, 32, 34]. We proposed a model accounting for the emergence of smiles synchrony depending directly on a "level of sharing" between agents (sharing of references, expectations, words, meanings). This model is based on the five followings:

- emit or receive a discourse modify the internal state of the agent [38],

- non-verbal behaviors reflect the internal states [25],

- humans are particularly sensitive to synchrony, as a cue of the interaction quality and and the mutual understanding between participants [8, 32, 34],

- sensitivity to synchrony can be modelized by simple model of reinforcement of the perception-action coupling [2, 30],

- synchronization can be modelized as a phenomenon emerging from the dynamical coupling within the dyad [35].

The consequence of the two first points is that, if agents' "level of sharing" is high, their non-verbal behaviors may synchronize, where as if their "level of sharing" is low, agents will not be able to synchronize. The three last points enabled us to build a dynamical model of the dyad, by implementing each agent as a neuronal network in the neuronal network simulator Leto/Prometheus (developed in the ETIS lab. by Gaussier).

The study of the dynamical properties of this dyad of agents shown that the synchronization of the smiling behavior of the two agents directly depends on their "level of sharing": If two agents have close levels of understanding, synchrony emerges between their non-verbal behaviors; Conversely, if two agents have too far levels of understanding, synchrony does not appear.

This synchronization also depends on how non-verbal behaviors reflects the internal states of the agent: for a low "level of sharing", many non-verbal behaviors do not favor synchronization, we can conjecture it reduces the significance of each non-verbal behavior; but for a high "level

of sharing", after induced de-synchronization, the more numerous are the non-verbal signal exchange, the faster is the re-synchronization.

Finally according to this model, the occurrence of synchronous smiles will depend both on the "level of sharing" and on the quantity of exchanged smiles: that suggest that the non-verbal behaviors are as much efficient as the agents are near and familiar.

4. DIFFERENT SMILES PATTERNS FOR AN AGENT

In the second study we search for different smile patterns that may be used by an embodied conversational agent to communicate amusement, politeness and embarrassment. These three different types of smile can be distinguished when displayed by humans because of several morphological and dynamic characteristics ([11, 20, 17]). In this experiment we check if the same set of characteristics can be used to differentiate these 3 different smiles in ECAs.

4.1 Experiment set-up

In order to identify the morphological and dynamic characteristics of the amused, embarrassed and polite smile of an agent, we have created a web application, called *E-smiles-creator*, that enables a user to easily create different smiles on an agent's face.

Using *E-smiles-creator*, the user can generate any smile by choosing the combination of seven parameters. Any time he changes the value of one of the parameters, a corresponding video is automatically played. Based on the research on human smile, we consider the following morphological and dynamic characteristics of a smile: the activation of AU6 (cheek raising), the activation of AU24 (lip press), the activation of AU12 (zygomatic major), the symmetry of the lip corners, the mouth opening, the amplitude of the smile, the duration of the smile and the velocity of the onset and the offset of the smile. Accordingly, on the right part of the *E-smiles-creator* interface the user may select these parameters of the smile. The video of the smiling agent will correspond to a smile with the selected parameters. We have considered two or three discrete values for each of these parameters: small or large smile (for the amplitude) (INT); open or close mouth (MH); symmetric or asymmetric smile (SYM); tensed or relaxed lips (for the AU24) (LT); cheekbone raised or not raised (for the AU6) (AU6); short (1.6 seconds) or long (3 seconds) total duration of the smile (DUR), and short (0.1 seconds), average (0.4 seconds) or long (0.8 seconds) begin and end of the smile (for the onset and offset) (OO). Considering all the possible combinations of these discrete values, we have created 192 different videos of smiling agent.

The interface of the *E-smiles-creator* is in French. The user can create one animation for each type of smile. Each time, the user also has to express his level of satisfaction concerning the smile he has created. The order of smiles to be illustrated as well as the initial values of the seven parameters are chosen randomly.

4.2 Results

By asking people through a web browser to participate to a study on smiles using *E-smiles-creator*, we have collected 1044 smile descriptions: 348 descriptions for each smile (amused, polite, and embarrassed). 348 subjects have

id	#	INT	MH	SYM	LT	AU6	OO	DUR
1	49	large	open	yes	no	yes	0.1s	3s
2	43	large	open	yes	no	yes	0.8s	3s
3	30	large	open	yes	no	yes	0.4s	3s
4	22	large	open	no	no	yes	0.8s	3s
5	21	large	open	no	no	yes	0.1s	3s
6	20	large	open	no	no	yes	0.4s	3s
7	9	large	open	yes	no	yes	0.1s	1.6s
8	8	large	open	yes	no	no	0.8s	3s

Table 1: The most frequently selected videos of amused smiles

Figure 1: Images of amused smiles at their apex with the id 1, 4, and 8 (see Table 1)

participated to this study (195 females and 153 males). Each participant has created one smile of amusement, politeness and embarrassment. The average participants' age is 30 years. The subjects are mainly French. In average, the subjects are satisfied by the created smiles (5.28 on a Likert scale of 7 points). Below, we describe the most frequent amused, polite and embarrassed smiles that appear in the smiles corpus.

Table 1 presents the characteristics of the most frequently selected parameter values of amused smiles. In the table, the second column (for instance # amused) represents the number of amused smiles (out of 348 amused smiles) defined with the parameter values of the line of the table. For instance, 49 out of 348 amused smiles have been defined with a large size, an open mouth, a symmetry, no lips tension, an activated AU6, an onset and an offset of 0.1 second and a total duration of 3 seconds (first line of Table 1). Globally, the amused smiles are mainly characterized by large amplitude, an open mouth, and relaxed lips. Most of them also contain the activation of the AU6, and a long global duration.

Table 2 illustrates the characteristics of the most frequently selected parameter values of embarrassed smiles. Compared to the amused smiles, the embarrassed smiles often have small amplitude, a closed mouth, and tensed lips. They are also characterized by the absence of AU6.

Table 3 describes the characteristics of the most frequently selected parameter values of polite smiles. The polite smiles are mainly characterized by small amplitude, a closed mouth, symmetry, relaxed lips, and an absence of AU6.

5. FUTURE WORKS

In this paper we presented three experiments on the role of smile in virtual agents. In the first experiment we showed the positive role of smiles backchannels for the conversation.

id	#	INT	MH	SYM	LT	AU6	OO	DUR
1	19	small	close	no	yes	no	0.1s	1.6s
2	18	small	close	no	yes	no	0.4s	3s
3	16	small	close	yes	yes	no	0.4s	3s
4	13	small	close	no	yes	no	0.8s	1.6s
5	11	small	close	yes	yes	no	0.1s	1.6s
6	11	small	close	no	yes	no	0.8s	3s
7	9	small	close	no	yes	yes	0.4s	3s
8	8	small	close	no	yes	no	0.4s	1.6s

**Table 2: The most frequently selected videos of embarrassed smiles**

id	#	INT	MH	SYM	LT	AU6	OO	DUR
1	16	small	close	yes	no	no	0.4s	3s
2	12	small	close	yes	no	no	0.8s	3s
3	11	small	close	yes	no	no	0.4s	1.6s
4	11	large	close	yes	no	no	0.4s	3s
5	10	small	close	yes	no	no	0.8s	1.6s
6	10	small	close	yes	yes	no	0.4s	1.6s
7	9	small	close	yes	no	no	0.1s	3s
8	8	small	close	yes	no	no	0.1s	1.6s

Table 3: The most frequently selected videos of polite smiles
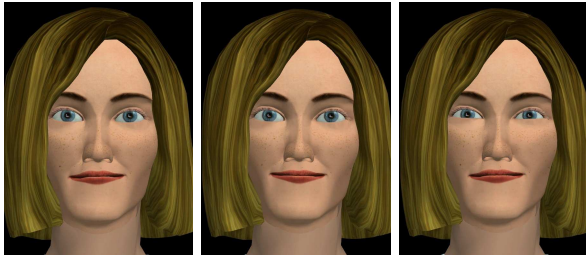
Figure 2: Images of embarrassed smiles at their apex with the id 1, 3, and 7 (see Table 2)

Figure 3: Images of polite smiles at their apex with the id 1, 4, and 6 (see Table 3)

In the second experiment, our dynamical model of smile synchronization suggested to link the familiarity of agents to the impact of their smiles. In the third experiment we found how the agent may display amusement, embarrassment and politeness.

We plan to continue the research on a *smiling embodied conversational agent*. First of all we prepare an evaluation of an ECA that displays in different contexts smile patterns discovered in Section 4. We are also working on putting together, in one integrated ECA, these patterns, the backchanneling rules of section 2 and the dynamical system approach of Section 3. Next, we would like to focus deeper on modeling the smiling behaviors in different social contexts. We are particularly interested in the smiling frequency and how the smiling frequency is related to some features of the interactants (gender, role, dominance). We will also analyze how the position of the smile during the speech act influences the meaning of this communicative act. We believe that all these works will make possible creating a smiling ECA.

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