Title	Managing agent's impression based on user's engagement detection
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Publication date	2019-07
Original citation	Mancini, M., Biancardi, B., Dermouche, S., Lerner, P. and Pelachaud, C. (2019) 'Managing agent's impression based on user's engagement detection', IVA '19 Proceedings of the 19th ACM International Conference on Intelligent Virtual Agents, Paris, France, 2-5 July, pp. 209-211. doi: 10.1145/3308532.3329442
Type of publication	Conference item
Link to publisher's version	https://dl.acm.org/citation.cfm?doid=3308532.3329442 https://iva2019.sciencesconf.org/ http://dx.doi.org/10.1145/3308532.3329442 Access to the full text of the published version may require a subscription.
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Item downloaded from	http://hdl.handle.net/10468/8313

Managing Agent's Impression Based on User's Engagement Detection

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ABSTRACT

When interacting with others, we form an impression that can be declined along the two psychological dimensions of warmth and competence. By managing them, high level of engagement in an interaction can be maintained and reinforced. Our aim is to develop a virtual agent that can form and maintain a positive impression on the user that can help in improving the quality of the interaction and the user's experience. In this paper, we present an interactive system in which a virtual agent adopts a dynamic communication strategy during the interaction with a user, aiming at forming and maintaining a positive impression of warmth and competence. The agent continuously analyzes user's non-verbal signals to determine user's engagement level and adapts its communication strategy accordingly. We present a study in which we manipulate the communication strategy of the agent and we measure user's experience and user's perception of the agent's warmth and competence.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Interactive systems and tools*;

KEYWORDS

Embodied Conversational Agents, Warmth, Competence, Engagement, Impression Management, Non-verbal Behavior

ACM Reference Format:

Maurizio Mancini, Beatrice Biancardi, Soumia Dermouche, Paul Lerner*, and Catherine Pelachaud. 2019. Managing Agent's Impression Based on User's Engagement Detection. In *ACM International Conference on Intelligent Virtual Agents (IVA '19), July 2–5, 2019, PARIS, France.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3308532.3329442

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IVA '19, July 2–5, 2019, PARIS, France

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM
https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

Engagement is an important aspect in human-agent interaction. By maintaining a high level of engagement we ensure that the interaction between user and agent will move forwards [16],[8]. During an interaction, user's impressions of a virtual agent are critical since they can influence user's engagement and her willingness to continue dialoguing with the agent [6]. A virtual agent capable of managing the impression that it generates towards the user will improve the quality of the interaction, in particular user's engagement. The process of *impression management* [10], that is, the attempt to control the impression given to the others, is highly influenced by non-verbal behavior [9]. In our work, we are interested in managing agent's non-verbal behavior to convey different impressions of Warmth and Competence (W&C), two fundamental dimensions in *impression formation*, in order to affect user's engagement during the interaction. The agent will dynamically change and adapt its behavior depending on the detected user's engagement. We expect that dynamic variability in agent's behavior (vs. a static approach) will positively affects user's engagement, as observed by [5]. An evaluation study run to validate our system is presented in Sec.3.

2 REAL-TIME USER-AGENT INTERACTION

We conceived a system architecture to enable the interaction between a virtual agent and a user. We implemented software modules to capture user's behavior (speech, facial expressions, head and trunk orientation), analyze/interpret it to detect the user's level of engagement and decide what the agent should say and how (i.e., the non-verbal behaviors accompanying speech). The agent's speech and behavior are dynamically selected not only based on the user's detected level of engagement but also by taking into account the agent's self-presentational intention. That is, the agent has the goal of communicating a given level of W&C that will influence the choice of its verbal and non-verbal signals to be produced.

The 2 main parts of our system for real-time user-agent interaction are illustrated in Figure 1:

(1) *User's Engagement Detection* - The EyesWeb open source platform [18] extracts: (1) user's non-verbal signals (i.e., trunk and head orientation) from Kinect data; (2) user's face Action Units (AUs) by running the OpenFace framework [2]; (3) user's speech. Based on the extracted signals, the open source platform computes user's engagement.

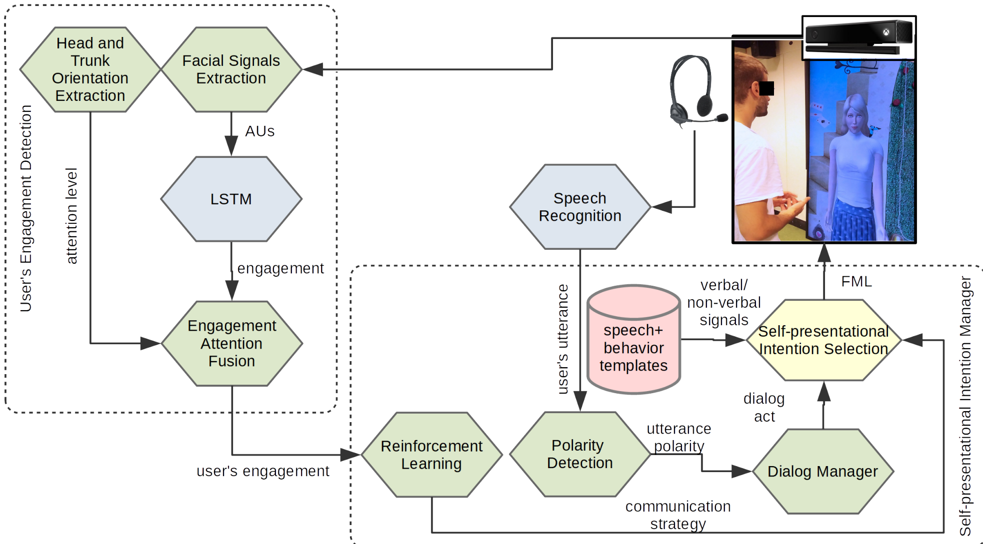

Figure 1: System architecture: user's non-verbal and verbal signals are extracted and user's overall engagement, computed by EyesWeb, is provided to the Self-presentational Intention Manager that decides the verbal and non-verbal signals to be produced by the virtual agent Greta.

(2) *Self-presentational Intention Manager* - The Greta platform [13] generates the behavior of a virtual agent endowed with a self-presentational intention manager (SPIM), implemented with Flipper [17]. The agent can choose among 1 out of 4 self-presentational strategies, inspired from Jones & Pittman's taxonomy [11], which aim to convey different levels of W&C: *ingratiation*, to elicit impressions of high warmth; *supplication*, to elicit impressions of high warmth and low competence; *self-promotion*, to elicit impressions of high competence; *intimidation*, to elicit impressions of low warmth and high competence. Each strategy is realized in terms of the verbal and non-verbal behaviour, according to [3, 7, 15]. The SPIM includes a Reinforcement Learning (RL) algorithm that, given the user's detected engagement and speech, chooses the self-presentational strategy to perform.

3 EVALUATION

We conducted an evaluation to test the hypotheses: (**h1**) each communicative strategy would elicit the right degree of W&C; (**h2**) an agent using our RL algorithm to adapt its behaviors according to user's engagement would improve user's perceived quality of interaction, compared to a non-adapting agent; (**h3**) our model would influence user's perception of agent's W&C.

3.1 Experimental Design

The design included one independent variable, called **Intention Selection**, with 6 levels determining the way agent's behavior is generated:

(1) **DYN_ADAPT** - use the W&C model;
(2) **DYN_RND** - random behavior at each speaking turn;
(3) **STATIC_INGR**, always adopt the *ingratiation* strategy during the whole interaction;
(4) **STATIC_SUPP**, always adopt the *supplication* strategy during the whole interaction;
(5) **STATIC_SELF**, always adopt the *self- promotion* strategy during the whole interaction;
(6) **STATIC_INTIM**, always adopt the *intimidation* strategy during the whole interaction.

The RL algorithm was exploited in the **DYN_ADAPT** condition only, and was removed in the remaining ones. Before starting the interaction, participants were asked to fill in a questionnaire about their attitudes towards virtual characters, adapted from NARS questionnaire [12]. The other dependent variables concerned two main areas of interest: user's perception of agent's W&C, and user's experience of the interaction. To measure the first area, participants were asked to rate their level of agreement about how much each adjective from a list better described the agent (4 concerning warmth, 4 concerning competence, according to [1]). To measure the second area, we analyzed participants' verbal behavior during the interaction, and, after the interaction, we asked participants to complete a questionnaire including items adapted from [4]. The questionnaire included: user's interaction satisfaction; her willingness to continue it; how much she liked the agent; how much she learned from it; how much she wanted to visit the exposition; where she would place the agent in a scale from computer to person; where she would place it in a scale from a stranger to a close friend.

3.2 Procedure

We conceived a scenario where the agent played the role of a virtual guide, introducing an exhibition about video games, held at the Cité des sciences et de l'industrie, the biggest science museum of Paris. The virtual character, called Alice, first introduced itself to the participant, and then provided several information about the exhibition. Each speaking turn included a dialog act of the agent (acted with the corresponding self-presentational intention), as well as the possible replies of the participant.

75 participants (30 females) took part in the evaluation, equally distributed among the 6 conditions. The majority of them were in the 18-25 or 36-45 age range and were native French speakers.

3.3 Results

Concerning user's perception of agent's warmth, we found an effect of **Intention Selection** on the ratings: warmth scores were significantly lower for **STATIC_INTIM** (multiple comparisons t-test have been run, all p-adj < 0.05). A main effect of NARS scores was found: participants with higher scores in this questionnaire rated the agent warmer than participants with lower scores in NARS questionnaire ($F(1, 62) = 5.74, p = 0.02, \eta^2 = 0.06$; $M_1 = 3.74, M_2 = 3.33$). No differences were found in competence scores.

These results partially validate **h1**: agent's self-presentational strategies are well recognized in terms of warmth, while they do not differentiate in terms of competence. The fact that when the agent displays coldness (i.e. in **STATIC_INTIM** it is judged by users with lower ratings of warmth compared to the other conditions) is in line with the positive-negative asymmetry effect [14].

They also partially validate **h3**: our model affects the perception of agent's warmth. This result is interesting, as it suggests a relation among agent's adaptation, user's engagement and warm impressions: the more the agent adapts its behavior, the more it increases user's engagement and user's perception of agent's warmth.

Concerning user's perception of the interaction, all the results we report below are statistically significant (all $p < 0.05$). A main effect of NARS scores was found for many items about user's perception: participants with higher NARS scores were more satisfied by the interaction, more motivated to continue the interaction, liked the agent more, and found the agent to be less close to a computer than participants who got lower NARS scores.

We also found a main effect of **Intention Selection** on some items: participants in **STATIC_INGR** were more satisfied and they liked the agent more than participants in **STATIC_INTIM**. In addition, we found that participants in the age range 55+ were more satisfied than the younger participants.

These findings do not refer to **DYN_ADAPT** condition, so we cannot validate our hypothesis **h2**. Anyway, they show another effect, that is, the agent displaying warmth (i.e., in **STATIC_INGR** condition), positively influenced the ratings of user's satisfaction.

4 CONCLUSION

Our system presented some limitations: questionnaires about interaction quality showed that most of participants did not like the agent appearance, voice and animation. Some of them described the experience as "disturbing", "creepy". So, probably, our agent failed to provide a positive very first impression, which negatively affected the entire experience. Due to the physical setup of the experiment, most of the participants barely performed any non-verbal behavior during the interaction with the agent. Then, our system could not reliably detect participant's engagement and consequently plan the best agent's self-presentational strategy. Finally, agent's strategies did not focus on building a rapport: it just managed its impressions of W&C without considering the social relation with the user.

In the future, we aim to implement another study involving a richer palette of non-verbal behaviors to be performed by participants: we will add conversational strategies related to rapport, e.g., self-disclosure, enhance the gaze behavior of the agent to improve mutual attentiveness, and endow it with non-verbal listening feedbacks, e.g., postural mimicry and movement synchronization.

ACKNOWLEDGMENTS

The work received funding from: EU Horizon 2020 research and innovation program under Grant Agreement Number 769553; ANR project Impressions ANR-15-CE23-0023. Authors want to thank the Carrefour Numérique of Cité des sciences et de l'industrie for hosting the study.

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