

Affect Listeners - From dyads to group interactions with affective dialog systems

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Abstract. Affect Listeners are applied as tools for studying the role of emotions in online communication. They need to interact both in dyads as well as in group settings with multiple users. In this paper, we present the evolution of such affective dialog systems from a focus on dyadic interaction to multi-party interaction on chat networks. Starting from experiments on the use of these dialog systems in virtual dyadic settings, we outline the requirements, design and implementation decisions necessary to apply the systems to affective interactions with multiple users. Finally, we introduce two realisations of Interactive Affective Bots designed for such interaction scenarios that integrate modelling of individuals and groups as part of their decision mechanism.

1 Introduction

The project CyberEmotions² deals with modelling and understanding of the role of *collective emotions* in creating, forming and breaking-up of online-communities. As part of the Cyberemotions project, the development and experimental evaluation of affective dialog systems that interact with users of network communication channels is undertaken [22, 19]. These systems serve two purposes: i.) a study tool for investigating the role of emotions in online communication and affective human-computer interaction, ii.) a support tool for e-communities providing online analysis, simulations and predictions for group dynamics, in particular addressing their affective dimension.

To date, Affect Listeners were applied in a range of experiments in dyadic settings which served to evaluate the systems' ability to participate in a realistic and coherent dialog and to establish and maintain an emotional connection with a user; and extended the understanding of the impact of affective system profiles and fine-grained communication scenarios on the self-reported emotional changes of users, their communication style and textual expressions of affective states. The next step, the application of such systems to group interactions created a new set of challenges related with, e.g., simultaneous communication with multiple users, capacities to interact in a way which intentionally follows or violates the typical communication patterns of members of a particular e-community, including the affective dimension of such interactions, or the ability to observe such a behaviour in other participants. These functionalities impact the system's ability to generate consistent or intentionally inconsistent interactive behaviour, the required affective coherence and the

event-dependent adaptation of its communication patterns to other members in a group. In parallel, the system needs to represent and model discussions and emotional exchanges, at the individual and group levels, to provide the foundation for predicting the possible outcomes of the observed group dynamics, for simulating the effects of system's interactions with individuals or a group, and finally to assess the real effect of its interventions and to correspondingly update the used models.

To address the requirements related with transferring Affect Listeners from dyadic to multi-user interaction settings, the proposed approach integrated experience gathered in experiments in dyadic settings with insights acquired from a wide range of studies on the role of emotions in online communication: psychological studies and experiments on perception and generation of emotionally charged online content [11] [12] [14], agent based models of emotions [21] [5], valence trends [2], agent based model on bipartite networks [15], and event-based network discourse analysis [8]. Potential applications of such systems include support tools for online communities, e.g., providing information on the current affective state of groups, or forecasting the changes in groups' affective states or interaction dynamics.

In the remainder of the paper, we present the concept of Interactive Affective Bots (IAB) and an overview of experiments with one of the system's realization in dyadic settings. Next, based on the experiences with Affect Listener systems obtained in dyadic interaction settings and modelling of affective interactions in e-communities, we outline the requirements, design and implementation decisions necessary to apply the systems to affective interactions in multiple users environments. Finally, we introduce two realisations of IABs designed for such interaction scenarios that integrate modelling of individuals and groups as part of their decision mechanism. We conclude by discussing the relevance of the presented approach to the goals of the Turing Test, and discuss new challenges and opportunities related with the application of artificial systems for interactions and cooperation in online environments that include large number of users.

2 Interactive Affective Bots

The specifics of online, real-time and unrestricted interactions with a wide range of users influenced the selection of methods and design decisions in IAB. In particular, we aimed at: (i) robustness regarding erroneous natural language input, (ii) extensibility regarding system components and application scenarios. (iii) responsiveness; both for the generation of system responses and for simulations of individ-

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² <http://www.cyberemotions.eu/> (all URLs last accessed 2012-04-05)

ual users' and collective emotions of the e-communities. Below we provide an overview of the main system components. For a detailed description of the system architecture and components used refer to [22, 24, 25]. At the top level layer, each realisation of IAB share the same structure, which includes Communication, Perception and Control layers presented in Fig 1.

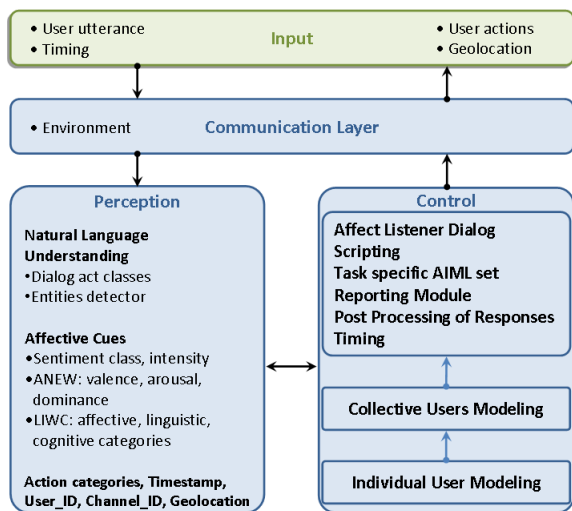


Figure 1. Interaction loop and generic architecture of Interactive Affective Bots

The Perception Layer, cf. [23], annotates both user utterances and system response candidates. This includes sentiment class and negative/positive sentiment strength [17]; valence, arousal and dominance [1]; various linguistic, cognitive and affective categories from the LIWC dictionary [18]; dialog act classes [23].

The Control Layer manages the dialog progression by relating observed dialog states to intended ones (e.g., querying and follow-up questions on the user's affective states, realizing a particular communication scenario) using the cues provided by the Perception Layer. This layer selects the system response from a number of generated response candidates, integrating rule-based action selection - Affect Listener Dialog Scripting (ALDS) - with the command interpreter for the task specific Affect Listener AIML-set³. As detailed in this paper, the control layer also integrates modelling of users, individuals as well as groups such as chat rooms, as part of its decision mechanism.

The Communication Layer handles the reception and dispatching of user/system utterances and provides the system with an interface to a range of interaction environments such as: Web Chat, 3D event engine[7], ICQ, XMPP (Jabber, Google or Facebook Chat).

The specification of an IAB includes the following layers of perception and interaction analysis:

1. Single utterance: annotation based on the Input Perception tool, a set of rules for generating system responses (Input Processing, AL-AIML [23])
2. Ongoing conversation: perception and analysis of the conversation context, tracking of effects of previous utterances (Input Processing, ALDS [22])
3. Individual and collective user modelling: long-term communication patterns or "personalities" of users regarding their textual expressions of affective states, characteristics of interaction patterns

³ Artificial Intelligence Markup Language (AIML)

and sentiment expressions of groups of users and user populations (CybABMod - see section 4.4)

2.1 Dyadic Interactions - Dialog Participant

The Dialog Participant realization of IAB is primarily applied for managing text-based communication with a user in an online, 1-on-1 interactive environment. It analyses and responds to the changes of the user's emotional state, i.e., textual expressions of affective states detected in the user's utterances. The typical objectives for the system in this interaction scenario include:

1. Realistic and coherent dialogs,
2. Conducive setting for communication (i.e. acquisition of large data sets),
3. Task-oriented dialogs related to "hot topics" in order to acquire users' affective states and stances towards the issues,
4. Studying the role of emotions in 1-on-1 HCI, e.g., the ability to consistently generate a particular affective profile and analysing its impact on users' self-reported emotional changes or textual expressions of affective states; or to convincingly realize a specific communication scenario, e.g., "getting acquainted with someone", "social sharing of emotions", throughout the whole time-span of communication with users and measuring their effects on users' communication patterns or their influence on system evaluation results.

3 Experimental results - Dialog Participant

System evaluation in a Wizard-of-Oz setting The first round of experiments was conducted in a Virtual Reality environment (see [7] and [24] for more details on the evaluation), where the dialog system was compared with a Wizard-of-Oz setting (WOZ)⁴, in terms of its ability to: establish an emotional connection, dialog realism, and providing an enjoyable chatting experience. After each of the experimental interactions, participants were asked the following questions for assessing the dialog system, represented as a Virtual Human (VH):

1. Did you find the dialog with the VH to be realistic?
2. How did you enjoy chatting with the VH?
3. Did you find a kind of emotional connection between you and the VH?

The results achieved by the dialog system matched those obtained for the WOZ condition, i.e., there was no significant difference between the two settings.

Impact of system's affective profile We define *artificial affective profiles* as a coarse-grained simulation of a personality, corresponding to dominant, extroverted character traits, that can be consistently demonstrated by a system during the course of its interactions with users [25]. In a second round of experiments, three distinct affective profiles were implemented in the dialog system: positive, negative and neutral. Each affective profile aimed at a consistent demonstration of character traits of the system that could be described as:

- cooperative, emphatic, supporting, positively enhancing, focusing on similarities with a user - (positive),

⁴ Participants believe that they communicate with a dialog system, while responses are actually provided by a human operator. In the presented experiments, the operator was asked to conduct a realistic and coherent dialog and provided free text input to user utterances.

- conflicting, confronting, focusing on differences - (negative),
- professional, focused on job, not responding to affective expressions - (neutral).

In these experiments, a browser-based communication interface, resembling a typical web chat-room environment was developed: a user input field at the bottom of the screen and a log of communication above. Participants interacted with the IAB in an unsupervised manner and were aware that they talk with an artificial system.

The results, presented in more details in [25], demonstrate that the implemented affective profiles to a large extent determined the assessment of the users' emotional connection and enjoyment from the interaction with the dialog systems, while the perception of core capabilities of the system, i.e. dialog coherence and dialog realism, were only influenced to a limited extent. Further, the self-reported emotional changes experienced by the experiment participants during the online interactions were strongly correlated with the type of applied profile. The affective profile also induced changes to various aspects of the conducted dialogs, e.g., communication style and the users' expressions of affective states. These results suggest that the participants, under this condition, assumed a more open, positive, sharing oriented attitude [26], which is also in line with the theory on Interpersonal Complementarity [13], which suggests that people in dyadic interactions negotiate their relationship through verbal and nonverbal cues, where dominant-friendliness invites submissive-friendliness whereas dominant-hostility invites submissive-hostility, and vice versa.

4 Scaling up to multiple users environments

4.1 Goals of IABs in multiple users environments

The experiments described above demonstrated that in the presented evaluation settings (VR or online web chat, relatively short interaction time) the system is able to conduct a realistic, enjoyable interaction and to establish an emotional connection with a user matching the results obtained in the WOZ setting. Further, the application of affective profiles showed an effect on self-reported emotional changes experienced by participants during the interaction with IABs, influencing also the textual expression of affective states and, to a smaller degree, the perception of core functionality of the artificial interlocutor, i.e., dialog realism and coherence.

The systems targeted at multi-user environments are primarily focused on supporting these e-communities by providing information - on demand or time-based - about a group's interaction dynamic, affective state, outcomes of the simulations regarding those parameters and exhibit relatively low activity levels in terms of direct communication with users. For groups, an IAB can track both content and affective dimensions of the communication between multiple users.

4.2 Role of simulations in IAB

The role of agent-based modelling and simulation in this kind of interactive system is two-fold: to provide part of the information provided to participants and to serve as decision support. Based on a request from a particular online community the tools can support it with analysis on affective dimension of their interactions and provide suggestions on ways for counter-acting negative tendencies observed in a group, e.g., a decrease of cooperation or growing hostility between members. Further, simulation results can indicate targets for interventions. This entails several requirements that concern both the results of simulation runs as well as runtime characteristics and the

adaptability of the simulation based on data collected during previous interactions. At this level, several questions relevant as a potential input for the systems' decision making mechanisms were identified [19]:

- Which individual in a group will be most likely to provide an accurate response to probing about the group's emotional state, and which one will be most reliable?
- What influence can individuals have on the evolution of the collective emotions in an e-community, and which of the specific participants is likely to have the biggest influence?
- Can potential escalations, both in the negative and in the positive direction, be detected early on?
- What influence will a specific intervention of the system have at the current moment, and which style of intervention is most effective?

Running a simulation on demand to query about the above questions adds the requirement of timely, or possibly anytime, responses but also the need to parameterise the simulation to quickly adapt to the current state of an e-community, ideally using the recorded history as input.

An important part of the decision-making structures of IABs is the modelling of conversation participants. This component of the agent control structure is analogous to adaptive user modelling in standard Human-Computer Interaction: the system initially has a default model of the interaction partner, adapts it over time, and complements missing information based on the knowledge derived from interaction events. In the case of multi-user environments, this includes modelling several participants, simplifying the employed models and abstracting from specific individuals.

The modelling eventually serves the purpose of deciding on utterance selection, utterance modification, timing of utterances, and the selection of conversational partners in multi-user environments. As such, the main questions that modelling efforts help to answer for the purposes of affective interactive systems are, from general to specific:

1. What potential influence will certain interventions have on the collective state of an online community?
2. What is the influence of particular interventions on the future development of a specific group?
3. What type of intervention (affective charge, topic, timing) will have which effect?
4. What relation does a particular individual have to the state of a specific group?
5. Which intervention is most appropriate when addressing a particular individual of a specific group?

4.3 Input from theoretical modelling and analysis

The general framework for modelling the emergence of collective emotions in IABs is based on the concept of Brownian agents [21]. This framework also serves as the reference point for modelling individual emotions. A promising effort is the study of emotional trajectories in online communities. Based on the analysis of Internet Relay Chat (IRC) data⁵ [20] [5], candidate methods have been identified

⁵ Analysed data-set included 2.5 million posts acquired from EFNET IRC chats: <http://www.efnet.org>, covering a range of topics including music, casual chats, business, sports, politics, computers, operating systems and specific computer programs.

for inclusion in IABs. Similar to the idea of following the norm behaviour of a channel, further channel characteristics regarding fluctuations of behaviour over time allow to use the concepts of “synchronisation” and “desynchronisation” with a dominant channel specific interaction pattern as decision factors. Synchronisation here refers to the relation of the affective content of system utterances to the affective content of users’ communication behaviours, i.e., positive or negative valence, high or low arousal. The application of Detrended Fluctuation Analysis[10] and the use of the Hurst exponent[9] to classify user behaviour in the long-term provide the basis for a long-term variant of synchronisation between user behaviour and system behaviour. Applied to a channel as a whole rather than per user, it provides an additional input for decision making that aims for influencing the overall channel state into a particular direction.

As demonstrated in [2], the probabilities of submitting consecutive messages of the same emotional valence increase as power-law with the number of already inserted messages⁶. For the purpose of decision-making in IABs, this can be directly translated to utterance modification, using a different target valence depending on the number and dominant valence of previously seen utterances. With this approach the IABs can conform to or violate a typical behaviour on a specific online communication channel or observe such interaction patterns in other participants. Further, based on the analysis of dialogue regarding ending and entropy, it was shown that the average emotional value increases during the dialog and that the probabilities of positive and objective valences in the comments equalize in the vicinity of the discussion end.

The network mapping approach [6] analysis⁷ account for the properties of activity patterns and underlying network topologies characteristic for various types of users, including those identified as important/influential in a given online interaction environment. In IABs, the spanning trees analysis can be specifically applied to analyze: i) user’s activity, i.e.: by the creation and analysis of evolution of the network links, e.g., positive, negative, and ii.) users collective behaviour patterns. As demonstrated in high-resolution analysis of user-to-user communication in IRC channels, only certain links survive over one day period and support a particular type of network structure. Based on this observation, the presented system realizations and application scenarios presented in sections 5.1, 5.2 are primarily targeted at serving on-demand information requests of e-communities or individuals, i.e., establishing a relatively short-time direct communication links. As experimental evidence demonstrates (see section 3), such direct, limited in time interactions with users, also contribute to an overall higher level of the perceived realism, dialog coherence, the feeling of an emotional connection and chatting enjoyment. In practical application and deployment scenarios, this often translates to a higher acceptance rate of interactive systems in online communities.

Overall, in the case of online communication channels such as IRC, an IAB can use observed increase of entropy in dialogues as a guiding factor for decision making. The insertion of objective comments or of equalising comments can potentially be used to further different goals regarding the wanted discussion length, i.e. either extending it or ending it earlier. Finally, another helpful global characterisation is provided by the analysis of the length of emotional clusters, indicating presence or absence of collective emotions in the discussion.

⁶ Analysed data-set included 4 million post acquired from Blogs, Digg and BBC forums.

⁷ Analysis conducted on extensive data-sets from Ubuntu IRC channels: <http://irclogs.ubuntu.com/>

4.4 IAB - Modelling Individuals and Groups

Based on data on previous or the recent part of current interactions with a certain group (e.g., a chat room or a discussion channel), the agent control architecture of the IABs uses an online simulation model, *CybABMod* - Cyberemotions Agent-Based Modelling module, parameterised by the population and the history of the current channel, to derive particular models for the individuals it interacts with as well for the group as a whole. The output of such a simulation is a very short-term prediction, with a necessarily modest precision, of suitable candidates for interaction.

On the individual level, this model corresponds to the inference of specific “personalities” or personality types. These personalities are characterised by a collection of decision rules that abstract from previous interactions for that individual. A default personality is assigned to newcomers to a channel based on average behaviour of the channel so far. The simulation is updated online based on the tracked history and provides both short-term predictions as well as global attributes based on the theory input described above.

Representation of Networks and Interactions A prerequisite to use modelling and simulation as part of the online decision structure, i.e. while interacting, is a suitable and flexible representation of interactions with the specific group that the system faces. In order to provide for that, we developed online data structures using the common terminology introduced by [8] layered on top of the HDF5⁸ disk and memory data format [27]. The latter provides a suitable framework for both logging and analysis of chat-specific data as well as for configuration and initialization of online simulation at runtime, both for several networks concurrently.

Varying Degrees of Affective Capabilities The baseline for the simulation of communicating agents or nodes uses stochastic modelling. One of the goals of this approach is to iteratively enhance the operationalisation of appraisal processes as described in theories of emotion [3, 4]. The minimum requirements for the modelling of appraisal processes in our nodes are representations of an agent’s concerns or desires, including standards about praise- or blameworthy behaviour, as well as preferences for certain types of objects or situations. Further, a method for evaluating changes in an agent’s environment based on these conditions is needed. For the purpose of e-communities, the changes to be evaluated encompass the posted messages and their content as far as it is modelled, but also the perceived entrance or exit of a participant in a discussion thread.

The modelling of a complete affective architecture is not the goal for these simulations. However, the introduction of specific *surface concerns*, i.e., concerns related to actual message exchanges as far as they can be observed, and a suitable approximation of an agent’s evaluation processes can be used to account for observed behaviour in e-communities.

5 Realization of Interactive Affective Bots for Multiple User Environments

Below, we introduce two realisations of IABs that integrate modelling of individuals and groups as part of their decision mechanism.

⁸ <http://www.hdfgroup.org/HDF5>

5.1 Affective Interaction Analyser

In the default settings for multi-user environments, such as e.g. IRC or Reddit⁹, the Affective Interaction Analyser (AIA) focuses on the analysis of the interaction patterns, affective content of the exchanged textual messages between the discussion participants and the tracking of group-level attributes characteristic of the affective group dynamic (see section 4.3). The content of the collected messages feeds into the tracking of the current observed affective state of a group, is part of the input to the CybABMod simulation, and thus influences the predictions of the possible outcomes of ongoing interactions. Similarly, like in previous realizations of the system, the AIA's architecture includes three layers: perception, control and communication. The functionality of the layers was however extended to allow for simultaneous perception of users' actions in a multiple users environment. This functionality provides a base, both for the analysis of individual users activities and for modelling of the whole group. Based on the input from the environment (e.g. system messages for an IRC channel as well as the formatting of messages), the perception layer identifies users' IDs and the range of actions typically performed in an interaction environment, e.g., joining and leaving a channel, changing a nick-name, posting a link or utterance. This realization of the system, is the least active in terms of interactions with casual users. In these settings, the bot's interaction capabilities are typically limited to infrequent messages that can be provided to selected participants, in particular to the channel operators in the case of IRC channels or the subreddit moderators in the case of Reddit, e.g., on demand or based on a set interval or threshold set for the observed affective and interactive states of a group.

5.2 Affective Supporter and Content Contributor

Depending on the foreseen experimental settings and tasks for IAB, the activity level settings for the bots in an environment such as e.g. IRC or Reddit, can be set between the two above presented conditions "Dialog Participant" (highest activity level) and "Affective Interaction Analyser" (lowest activity level), enabling the Affective Supporter and Content Contributor (ASCC) to participate to a moderate extent in an ongoing discussion by providing both new content, related to the discussed topic (e.g., link to a relevant website) or the results of affective group dynamic analysis and real-time simulations. This realization of the system, relies on the architecture presented above, i.e., "Affective Interaction Analyser", extended to provide additional interactive capabilities targeted to the whole group such as posting comments (i.e., affect analysis based, relevant to the observed affective states of the group) or website links relevant to the ongoing discussion (i.e., content related [22]). In the Affective Supporter and Content Contributor scenario, the IAB combines the ability to directly respond to a range of events, such as:

- changes in the environment, e.g., a user joins/leaves the channel, posts a link or comment, (updating the interaction and group status, based on the set interval or threshold - sending messages to channel operator),
- changes in the affective state of the group, e.g., sudden decrease of the valence, increase of sentiment polarity in the posts exchanged between users,
- changes in the activity of the group. For example, the detection of a decrease of the participants activity might lead to emitting a message or posting a new link, or comment respectively, to a

single user as selected by the simulation model. Further, in this scenario the interactive bot can also provide information about an event from the "offline" world related to the discussed topics, or emit questions aiming to stimulate the interactions,

- responding to utterances or comments emitted directly to the IAB by users.

6 Conclusions and Discussion

To summarise, in the presented system applications, the system-user communication is text-based, real-time and oriented at the detection and acquisition of users affective states. Communication with the system is not limited to a specific domain, topic, or one particular ICT-mediated community. Naturally, interactive systems like these, are strongly limited in the sense that they cannot match the conversational abilities of a human, in particular in interaction scenarios that include long-term communication, and further which need to combine open- and closed-domain dialog and discourse processing. However, as the experimental evidence presented in section 3 demonstrates, in 1-on-1 communication settings and relatively short communication scenarios, i.e., chat sessions that are a few minutes long, the systems could match the WOZ results in terms of dialog realism, chatting enjoyment and the ability to establish an emotional connection with users. Further, the analysis of activity patterns and affective dimensions of users' communication in multi-user environments presented in section 4.3 showed that the majority of links are established only temporarily and primarily used to exchange relevant information, to share or respond to a sentiment expressed. These results support the proposed application scenarios where the systems establish communication links in a way similar to their human counterparts: on demand basis, and for a limited time-span. Consequently, the IABs communicate directly with users in situations where high confidence scores for a potential contribution's relevance, i.e. added informational or affective value - *contribution value*, can be foreseen. These estimates are based on the outcomes of the simulation of the reception of a specific content by a particular individual or a group. Additional *action costs* are associated with interaction scenarios where posts need to be emitted to a large number of participants or to the whole e-community.

Related to the classical Turing Test setup [28], the focus on other aspects than discussion content is sometimes used to deal with system confusion, e.g., system inability to respond based on analysis of semantic content, expected states in a dialog, pragmatic context or a simple detection of keywords. In the case of the presented systems, the focus on affective content is deliberate. This approach, i.e., generation of the selected system responses based on the detected affective states of individuals or groups can be seen as complementary to continuous extending and updating of knowledge bases necessary to respond to open-domain inputs. In a range of application scenarios, a pre-requisite for a successful application of such interactive systems could be the ability to adjust (or at least foresee the outcomes of an intentional violation of) one's communication behavior or affective stance according to: the overall mood detected in a group; individuals' preferences to various entities or fellow participants; the established or evolving "social norms"; or dynamic changes in a hierarchy of interaction patterns of users. Social intelligence also plays a role in a 1-on-1 interaction scenario, and as such is relevant for the Turing Test. However, the classical Turing Test was neither the primary goal of the Affect Listener systems nor required for them to fulfill their purpose. While the interaction is, as mentioned above, unrestricted, the domain is constrained in so far as the system concerns

⁹ <http://www.reddit.com>

itself mainly with the emotional states of individual participants as well as the dynamics of collective emotions and employs suitable strategies to keep the conversation or interaction between members going.

The setups in which an agent or group of agents interacts and cooperates with a large number of users provides new challenges but also offers new opportunities for the evolving intelligence and adaptability of the artificial systems. As demonstrated in nature, when the communities begin to evolve from a scenario of low cooperation, towards a more cooperative scenario, the more advanced solutions for intelligence are obtained. This is particularly relevant for the evolution of social intelligence: interactions that require indirect reciprocity, are cognitively demanding, or where individuals need to constantly monitor the social constellation of a group. Clearly, all of these factors - to a different degree - are present in different online communities, and need to be addressed to a possibly large extent, when envisaging new supportive roles for artificial agents in such multi-user settings. Such interaction settings also influenced the evolution of human language [16].

In this paper, we presented the design choices for using agent-based simulation as part of the decision mechanism of Affect Listeners. The use of the simulation as decision support for interactive affective systems adds different requirements including real-time and online use. Both of these connections contribute to the design of the simulation. The ALs are interactive affective systems that are also used for acquiring data, and for studying online interaction. The initial realisations of the systems were applied in dyadic experimental settings, demonstrating the ability to generate an enjoyable and realistic dialog on par with WOZ settings. Further, using the AL, we studied the role of affective profiles in dyadic settings. For future work, we are interested in measuring the effect of the interactions with the systems on participants' emotional (physiological) responses and to relate and align those with the textual expressions of users' affective states observable during interaction.

ACKNOWLEDGEMENTS

The work reported in this paper is partially supported by the European Commission under grant agreement CyberEmotions (FP7-ICT-231323). The Austrian Research Institute for AI is supported by the Austrian Federal Ministry for Transport, Innovation, and Technology.

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