Group Affective Tone Awareness and Regulation through Virtual Agents

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Abstract. It happens increasingly often that experts need to collaborate in order to exchange ideas, views and opinions on their path towards understanding. However, every collaboration process is inherently fragile and involves a large set of human subjective aspects, including social interaction, personality, and emotions. In this paper we present Pogat, an affective virtual agent designed to support the collaboration process around displays by increasing user awareness of the group affective tone. A positive group affective tone, where all the participants of a group experience emotions of a positive valence, has been linked to fostering creativity in groups and supporting the entire collaboration process. At the same time, a negative or inexistent group affective tone can suggest negative emotions in some of the group members, emotions that can lead to an inefficient or even obstructed collaboration. A study of our approach suggests that Pogat can increase the awareness of the overall affective state of the group as well as positively affect the efficiency of groups in collaborative scenarios.

Keywords: affective virtual agents, group affective tone, awareness

1 Introduction

It is not seldom that gaining insight into large, compound datasets requires the knowledge and experience of a diverse group of users. But while certain advantages can be achieved by harnessing the expertise of multiple users through collaboration, one needs to also consider the subjective human aspects that influence communication and cooperation. As such, a group of experts can only maintain their collaboration as long as subjective human aspects, like personality, emotions and social interactions, do not affect it negatively. One measure employed to express the subjective coherence of a group is the *group affective tone* (GAT) [10]. It is defined as the presence of homogeneous emotional states throughout the entire group, i.e., all group members present an affective state of similar valence orientation and value (e.g., all group members have very positive emotions).

In Proceedings of the IVA 2014 Workshop on Affective Agents, pages 9-16, Boston, MA, USA, 2014.

The group affective tone of a team can have multiple values. In configurations where the members of a group have diverse emotional states and valence, a GAT cannot be defined. However, in cases where all members have either a positive or a negative emotional state, the corresponding positive GAT (PGAT) or a negative GAT (NGAT) can be defined. More importantly, PGAT has been linked on multiple occasions to increased effectiveness and creativity levels in group settings [6, 14].

As our current research focuses on increasing GAT awareness in groups, we explored the literature for visual representations of affect. Sadly, there is only limited work on representing GAT or supporting collaboration with affective virtual agents. Potential representations for emotional states involve abstract visualizations [17, 5], interface widgets [16], as well as a range of affective icons and agents [9, 13, 16]. More importantly for our approach are the affective virtual agents used in collaboration-relevant contexts like frustration management [12], emotional self-awareness [2], empathy [7], and negotiations [1, 18]. Even more focused on collaboration, in [8] the Virtual Messenger system is highlighted which employs affective 3D animated avatars in order to capture and express the emotions of users in a communication setting.

In the following section, we highlight the specifics of Pogat, an affective virtual agent for increasing GAT awareness and aiding the development of PGAT in collaborative scenarios. Next, we present a user study capturing the effects Pogat has on groups that try to solve a task collaboratively on a tabletop display. Finally, we discuss advantages and potential pitfalls of our approach and offer our conclusions.

2 Awareness and Collaboration

In order to determine the GAT for a group, we need to have a method for interpreting the emotional states of each group member in real-time. While this is achievable through a set of technologies, for our context where users would interact and collaborate around a large display or tabletop, we focused on employing lightweight and portable electroencephalographic (EEG) devices for obtaining the current affective states of each participant (see Figure 1). Each member of a collaborative session is equipped with an EEG headset that is capable of capturing electrical signals from the user's scalp. These brain signals are interpreted as emotional states with the help of the Emotiv software framework and decomposed into values of emotional valence through the use of Russell's circumplex model of affect [19]. Note that the focus of this paper is not on the acquisition of the user emotional states with the Emotiv EPOC device. Our approach in this domain is similar to the ones presented and detailed in [3, 4], where an detection accuracy of up to 80% has been obtained when compared to user self-reports.

Once the emotional readings are obtained for each participant, the data is sent to the Pogat virtual agent system. The decision for employing an affective virtual agent for expressing GAT was influenced by an agent's natural ability to mirror user emotions, as well as the ability of an individual to better perceive

Fig. 1. Image of the Emotiv EEG neuroheadset (left). User wearing the EEG device while interacting with a computer (right).

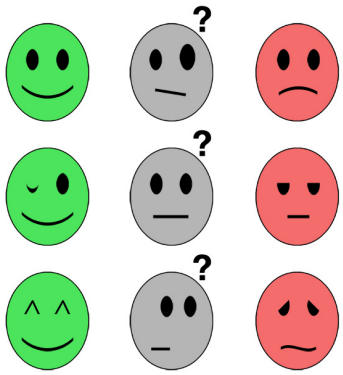

Fig. 2. Representations of the virtual agent encoding the valence of the group affective tone: group affective readings with a positive valence are expressed through corresponding facial expressions and green coloring of the agent (left); heterogeneous group affective readings in terms of valence are represented through facial expressions that suggest confusion and a desaturated color (center); a negative group affective tone is represented through corresponding facial expressions and a red coloring of the agent (right). The facial expressions of the agent are inspired by a subset of *emoji* faces.

emotional states through facial expressions than abstract representations. The Pogat system is comprised of two modules: one for analyzing the individual emotional states of the group members and extracting the GAT, and one for managing the representation and feedback offered by the affective virtual agent. For the computation of the GAT, the system checks the emotional valence of each participant by accessing the affective information derived by the EEG device and mapped in the normalized domain of valence $[-1, 1]$. This results in N readings V_N, where N is the number of group members and V_i is the current valence

of member i in the group, $-1 \leq V_N \leq 1$. If all valence readings have similar values, i.e. $V_i - V_j \leq k$ for any i, j in $[0, N]$ and k is a threshold with the default value of 0.25, then a GAT exists. Homogeneous readings in the positive space are interpreted as the presence of a positive group affective tone (PGAT), and homogeneous negative emotional states as negative group affective tone (NGAT).

These findings are represented by the second module by an emoticon-like agent that exploits the visual channel to offer feedback by modulating its facial expressions based on the current GAT of the group: expressions suggesting happiness correspond to the presence of a PGAT, expressions related to sadness correspond to a NGAT. And finally, neutral expression or expressions of wonderment correspond to a current lack of GAT (i.e., the group members have very different emotional states in terms of valence). To further enforce user awareness, Pogat modulates the color of the virtual agent by mapping it to the three potential GAT states (see Figure 2). The transitions between the represented GAT states are gradual, allowing for three seconds in which the agent slowly changes his expression and color.

3 User Study

We executed a user study in order to inspect the effects that our affective virtual agent would have on the GAT awareness and subsequently how this would affect group performance and interaction. Our study involved 12 participants divided in groups of three, with an average age of 22.5 and an equal male-female distribution. The experiment focused on finding particular subgraph structures in a time-series visualization running on a tabletop (see Figure 3). More precisely, the groups were asked to find specific patterns of user browsing behavior in a tabletop visualization of large datasets storing the browsing history of multiple users over multiple days.

After a brief introduction of the tabletop system and the Pogat agent, each group was engaged in six search tasks resulting in 24 executed tasks in total. The tasks of each group where divided into three categories: without the help of the Pogat affective agent, with the presence of the Pogat affective agent on the tabletop and with the presence of the Pogat agent that was also offering text-based suggestions for achieving a PGAT. For the third category, the agent was programmed to not only react and present the current GAT state, but also to offer a suggestion on how to achieve a positive group affective tone in cases when NGAT or the lack of emotional consensus (i.e., some group members presented a deviating and negative emotional valence) was present. The text-based messages of the agent were selected randomly from a predefined dataset and focused on tasks and actions shown to lead to a PGAT in certain conditions: taking a break or executing a short fun task, reevaluating previous decisions, or increasing group interaction and communication [15]. Note that the order of the tasks and appearance of the agent were randomized for every group, and that the timer measuring the efficiency during a particular task was stopped while the users were executing one of the agent-proposed suggestions.

Fig. 3. Users collaborating around a tabletop application while wearing BCI devices that interpret their affective states. The GAT virtual agent inspects these affective states and offers real-time feedback about the group affective tone, as well as suggestions for developing a PGAT.

The results of our study are highlighted in Figure 4. They suggest that employing a virtual agent for offering feedback about the GAT can significantly reduce the average task completion time by up to 26%. Further, the average times spent by each group without a GAT or in a NGAT present a drop in the two cases where the Pogat agent was used. Additionally, although the completion times are similar in the last two cases, it seems that employing an agent capable of offering concrete suggestions towards regulating the GAT improves the amount of time spent by a group in a no-GAT state, and increases the period of experienced PGAT.

Furthermore, an increased level of communication both about the task at hand and the group affective tone was noticeable in our study. Participants seemed to be more interested in addressing issues revolving around potential controversial group decisions (e.g., "I think we can combine these two filters for finding the longer active time. Does everyone agree with this?"). At the same time, post-task inquiries have shown that group members were mostly positive towards the use of an affective virtual agent for highlighting GAT, with 10 participants considering such a system as advantageous in supporting collaboration around large displays.

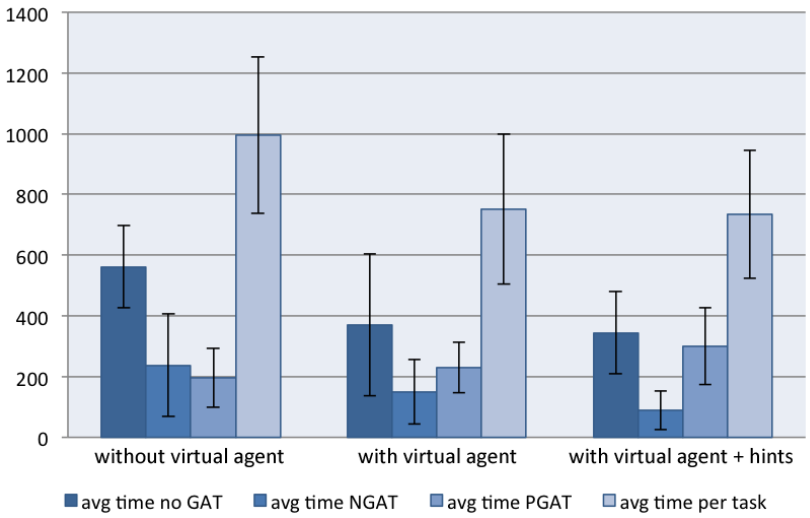

Fig. 4. Average times (in seconds) and standard deviation values for the three categories of tasks the groups had to solve: without the aid of the virtual agent (left), with the support of the virtual agent (center) and with the virtual agent offering also text-based hints (right). The four bars in each category encode (left to right) average time that the groups spent with no-GAT, negative GAT and positive GAT, as well as the average time that was necessary to complete the task. This average time is identical to the sum of no-GAT, NGAT, and PGAT.

4 Discussion

Maintaining good communication and frictionless collaboration is vital in a wide range of domains and multi-user systems. The awareness of the group affective tone, as shown in our study, has the potential to empower group members to take control over a degrading or erratic collaboration and guide it toward a more efficient configurations. Furthermore, affective agents like Pogat can, through their human-like representation and hint-based communication, have a principal role in managing feelings of frustration, supporting a positive group mood and even aiding conflict management in a team.

More importantly, as affective agents can be employed in a wide range of collaborative application (e.g., medicine, entertainment, emergency management, or visual analytics), it becomes clear that their effect is particularly valuable in sustaining the collaboration in contexts where *unanimous decisions* are of utmost importance. This is further supported by the link between a person's ability of recognizing emotions in others and her/him making a good decision [11]. Consider, for example, architects working in a collaborative setting. When decisions can have such a wide impact like in this field, it is required that all team members agree on decisions and their results. As such, one team member who does not express a different point of view on a certain topic can have serious reper-

cussions. Yet, in most cases, such a repressed action results in emotions that can be perceived by our system, thus, it makes the group aware of a discrepancy in the team.

Besides the importance of a unanimous group decision depending on the domain and complexity of the task, collaborative scenarios are also defined by the size of the group. As such, a negative or inexistent GAT can also have varying relevance for small and large groups, as the impact of a single person in a larger group can be less than the one of a person in a smaller group. However, this does not constitute a rule, as some domains require all participants to reach a common solution or conclusion (e.g. medicine, architecture, etc.). Thus, Pogat is aimed mostly at collaborative scenarios where every potential disagreement needs to be expressed and analyzed in order to ensure precision and safety.

Because the Pogat system raises awareness of the GAT and not the emotional levels of select individuals, it also addresses a set of *privacy issues* by offering a convoluted view and avoids segregating a person as the source of a problem in the team. At the same time, one has to consider that certain group members might feel uncomfortable with sharing their affective states, even in a summative fashion.

5 Conclusion

In this paper we have focused on presenting Pogat, an affective virtual agent for supporting collaboration through increased group affective tone awareness. Besides allowing group members to be aware of the current emotional state of the team, Pogat also supports the transition of a group to a more positive GAT. The emotion acquisition in our system is done by employing a set of mobile EEG headsets and extracting the real-time emotional valence of each user. On the other side, the Pogat affective agent increases GAT awareness in the team by modulating its representation through facial expressions, colors and text-based hints. Our study suggests that our virtual agent helped users to increase their GAT awareness and improve their efficiency on the proposed collaborative tasks.

In future research we plan to extend the interaction modalities of the Pogat agent as well as further inspect the efficiency of various techniques for manipulating group affective tone to support collaboration.

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