# Emotion Feedback during Computer-Mediated Collaboration: Effects on Self-Reported Emotions and Perceived Interaction

Gaëlle Molinari, Distance Learning University Switzerland & TECFA/University of Geneva, Sierre & Geneva, Switzerland, gaelle.molinari@unidistance.ch
Guillaume Chanel, Swiss Center for Affective Sciences, Geneva, Switzerland, Guillaume.Chanel@unige.ch
Mireille Bétrancourt, TECFA/University of Geneva, Geneva, Switzerland, Mireille.Betrancourt@unige.ch
Thierry Pun, Computer Science Department/University of Geneva, Switzerland, Thierry.Pun@unige.ch
Christelle Bozelle, Swiss Center for Affective Sciences, Geneva, Switzerland, Christelle.Bozelle@unige.ch

**Abstract:** Emotions play a crucial role in collaboration. They help to make inferences about the partner and can strongly influence task performance. Due to limitations of emotional cues in computer-mediated collaboration (CMC), the collaborative process can be impacted. In this study, we report on the effect of an Emotion Awareness Tool (EAT) designed to facilitate the sharing of emotions between partners, on the perceived emotions after collaboration and the perceived quality of the interaction. Results showed that the EAT stimulated participants to engage in a mutual modeling of emotions. In the EAT condition, the perceived amount of time spent on emotion modeling process was positively correlated to the perceived intensity of positive emotions after collaboration. The EAT increased the perceived degree of transactivity, but only for women. This study provides a first step in exploring the effect of emotion awareness in CMC tasks including a comparing approach for its gender-specific relevance.

## Introduction

There is now a large consensus among researchers on the fact that emotions impact a broad range of cognitive and social processes, and that humans are able to use emotional information to regulate their activity as well as to influence others (Van Kleef, 2009). A change in individuals' emotional states can reorient their attentional focus and induce a change in the way they think, act and interact with others. In cognitive theories, emotion is defined as resulting from the appraisal of (external or internal) events, involving the synchronization of 5 interrelated organismic subsystems. These subsystems underline the 5 components of an emotion, the cognitive, neurophysiological, motivational, motor expression and subjective feeling components (Scherer, 2005).

Emotions are strongly related to people's knowledge and goals, especially in high-order activities (learning, problem-solving, decision-making…) in both individual and group settings. For instance, when learning alone from a low cohesion text, or when solving an ill-structured problem together with a partner, individuals have to cope with many difficulties in, e.g., filling cohesion gaps in the text or converging on a joint solution in the discussion with the partner. Such coping is even more complex when individuals have low prior knowledge or when the difference in knowledge between collaborators is relatively high. On the one hand, encountering those difficulties may result in (socio-)cognitive disequilibrium than can produce negative emotions like confusion, frustration or boredom in case of persistent failure. On the other hand, positive emotions like satisfaction, pride and engagement/flow may occur when learners are successful in coping with their difficulties and as a result converge to a new equilibrium state. Positive emotions were found to be positively related to individual learning (D'Mello & Graesser, 2012). Moreover, a shift towards a more positive mood can increase flexibility and creativity thinking (Davis, 2009). The relationship between negative emotions and (socio-)cognitive processes is not so obvious: Whereas negative emotional states like frustration and boredom are detrimental to learning, there is a positive correlation between confusion and learning as it can stimulate active and deep processing (Lehman et al., 2012). This positive impact of confusion could also partly explain why in some cases, collaborative learning failure can be productive (Kapur, 2009). Besides studies on decision-making also found that people in a negative mood are more inclined to seek new information, engage in analytical information processing and produce higher quality decisions (van Knippenberg et al., 2010). Stemming from the field of affective computing (Picard, 1999), recent studies have proposed and shown the feasibility to build computer interfaces able to react to learners' emotions with the goal of improving learning outcomes (Kapoor et al., 2007). The above results and technologies clearly emphasize the need to better understand the role of emotions in individual and collaborative learning.

### Emotions in Social Interaction

The study of emotions in groups becomes an important research area in social psychology, and the focus is on how social processes influence the emotional feelings and expressions, and vice-versa. In an interpersonal approach of emotions, Van Kleef (2009) proposed the EASI (Emotions as Social Information) model as a framework to predict when and how the expression of emotions affects observers' behavior. In this model, there are two distinct but mutually dependent ways individuals can be influenced by their partners' emotional expressions in social interaction settings. On one hand, partners' emotions are processed below the conscious level and such processing results in affective reactions. This is the case when individuals automatically feel the same emotions than those felt by their partners through emotional contagion (Hatfield et al., 1993). Such emotional reactions are also recognized as playing a determinant role in interpersonal liking processes. On the other hand, individuals strategically and consciously use emotions to make inferences about their partner, and adapt their behavior in consequence (e.g., providing help when the partner displays frustration). According to Van Kleef (2009), both emotion-processing paths (affective reactions and inferences) can lead to similar (e.g., feeling compassion when seeing the partner in difficulty) or opposite (e.g., keeping calm when facing an angry partner) behavior. The use of one of these paths when processing emotional expressions also depends on both observers' epistemic motivation, their cognitive resources as well as the cooperative or competitive nature of the social situation. Individuals are more likely to engage in inferences about their partner's emotions when they are motivated to build and update an accurate representation of the situation and/or when this situation is perceived as competitive. The probability to use inferential paths also decreases with fatigue and time pressure.

Research also showed that the expression of emotions depend on sets of social (and cultural) rules determined by the characteristics of the social interaction, the nature of the collective work, as well as interpersonal power processes (Ragins & Winkel, 2011). This may explain differences between men and women in the expression of emotions (Brody, 2000). It has been shown that men are less likely to display emotions they experience than women – especially with other men, while women allow themselves more easily to express their emotions to a wider range of persons, independent of their gender (Rime et al., 1991). Moreover, Ragins and Winkel (2011) argued that in work contexts, women are expected to display emotions (compassion, worry or fear) that are usually related to less interpersonal power than emotions expected of men (confidence, pride or anger). From a gender/neural perspective, McRae et al. (2008) found no difference between men and women with regard to emotional reactivity; results suggest rather a discrepancy in the emotion regulation process. Men seem to be able to regulate their emotions with less effort and greater efficiency than women. Compared to men, women tend to generate positive emotions to a greater extent when trying to down-regulate negative emotions.

## Emotions in Collaborative Tasks

During the past five years, a growing body of research has focused on the role of emotions in collaborative learning (CL) situations, and more specifically on their relation to students' social-behavioral engagement (Linnenbrink-Garcia et al., 2011) and regulation processes during CL tasks (Järvenoja & Järvelä, 2009). CL situations can be viewed as being "more challenging than conventional and well-structured learning situations" (Järvenoja, 2010, p. 68), although the ultimate (shared) goal in such settings - that is, the construction of a shared understanding (Roschelle & Teasley, 1995) - can be associated with positive emotions and high motivation (Eligio et al., 2012). The CL process can be understood as an interpersonal matching process that evolves over time, that is, moment-by-moment during the course of interaction (and probably also after that). It is described as a constant adjustment of tension between interpersonal convergence (necessary for joint actions) and divergence (necessary for flexibility and creativity) in terms of perceptions, actions, knowledge and emotions. In the same vein, Andriessen et al. (2010) argued that there are two interrelated tuning processes during CL tasks, a cognitive tuning (confrontation/differentiation of ideas) and a socio-relational tuning (maintaining a collaborative working relationship). The CL experience is therefore characterized by continuous fluctuations of tensions and relaxations between learning partners. Tension may arise from the expression of divergent information (due to learners' differences in knowledge, intentions or cognitive abilities) and conceptual conflict; the greater is such a tension and "the more potential mutual gain is present in the situation" (Andriessen et al., 2010, p. 227). However, when the tension is too high and/or when the focus in the group shifts towards social comparison of competence (Darnon et al., 2006), negative emotions may emerge and as a result, learners try to protect their own competence (face-saving process and use of competitive strategies). Since negative emotions can impair learning, emotion regulation processes need to take place during interaction so as to reduce tension between partners. These emotion regulation processes are both individually and socially constructed (Järvenoja & Järvelä, 2009), and are motivated by the co-learners' need to converge towards a joint solution. According to Järvenoja and Järvelä (2009), the co-learners' efforts to overcome together socio-emotional challenges can be viewed as "critical points [...] in terms of successful learning and interaction".

## Emotion Awareness and Computer-Mediated Collaboration

Unresolved socio-relational tensions and the resulting negative emotions may have a dramatic impact on collaborative processes and outcomes. The understanding of the partners' emotions is thus necessary to trigger emotion regulation strategies that will favor successful collaboration. In this paper, we argue that emotion understanding is part of the mutual modeling process through which collaborators build a representation of what their partners know, believe and intend to do. In previous research (Molinari et al., 2009; Sangin et al., 2011), we found a positive correlation between the accuracy of mutual knowledge modeling and learning in Computer-Supported Collaborative Learning (CSCL) settings. We hypothesize here that individuals' ability to recognize and understand their partner's emotions also plays a crucial role in the way they communicate and build a shared understanding; such ability would facilitate processes such as audience design and perspective taking.

In face-to-face (F2F) situations, people rely on a whole set of explicit and implicit mechanisms to adapt to their partners and the situation. In computer-mediated collaboration (CMC), contextual non-verbal cues – such as facial expressions, head movement, eye gazes – are missing or seriously limited. The awareness of others may therefore be impaired and this may lead to inefficient interactions. In recent years, research has been conducted to investigate the role of emotions in CMC (Derks et al., 2007). These studies showed no differences between F2F and CMC settings with respect to expression of positive emotions and even suggest that people express more freely their negative emotions in CMC. Besides emoticons and acronyms (e.g., "lol") are regularly used in online interactions to express one's emotional states. However, men rarely use emoticons in conversation and feel less satisfied with CMC experiences than women (Lee, 2003).

The use of group awareness technologies is becoming widespread to circumvent the bottlenecks of CMC. Such technologies aim at analyzing users' characteristics and behavior and feeding that information back to the group. In CSCL contexts, group awareness tools are designed so as to improve and expand social and cognitive processes during collaborative learning (Buder, 2011), by making explicit and visible what is not directly observable like e.g., the group members' prior knowledge (Sangin et al., 2011) or their participation level during online discussions (Janssen et al., 2011). To our knowledge, there is still little research on the effects of *emotion awareness tools* designed to provide collaborators with information about their partner's affective states during online collaboration. Eligio et al. (2012) carried out experiments with the aim to investigate the relation between emotion understanding and performance in CMC. It is noteworthy to point out that only women participated in these experiments to "avoid the controversy of gender differences regarding the interpersonal understanding of emotions" (Eligio et al., 2012, p. 2049). Results showed that collaborators had difficulties to accurately assess their partner's emotions in CMC situations (Study 1). In order to overcome such difficulties, collaborators were instructed to share their self-reported emotions with their partner during specific moments of the task (Study 2). Results showed – for remote collaborators – both higher group performance and higher accuracy at estimating their partner's emotions in the emotion awareness condition. This suggests a positive impact of emotion awareness tools on collaborative processes and outcomes.

### Objectives and Research Questions

The aim of our research project is to explore the impact of reciprocal emotion awareness on collaborative processes and outcomes. The overarching goals are twofold: (1) To shade light on the benefits of providing emotional feedback in CMC situations, and (2) to resort on affective computing to develop adaptive collaborative "emotionally aware" systems able to automatically provide emotional feedback when necessary. In the reported study, participants were provided with an emotion awareness tool (EAT) with which they self-reported and shared their emotions *explicitly* during a computer-mediated collaborative design task. Our goal in this paper is to investigate the effects of the EAT on the subjective perception participants had of their collaborative work experience. More precisely, we wondered to what extent sharing emotional awareness information during remote interaction influences participants' perceptions (a) of both their own- and their partner's emotional states after collaboration (Question 1), and (b) of the quality of interaction with their partner (Question 2). By perception of the quality of interaction, we meant participants' perceptions of the frequency with which they (and also their partner) defended and argued their own ideas, built up on or challenged their partner's ideas as well as processed and managed emotions during collaboration. Unlike Eligio et al. (2012), both women and men participated in our study (they were paired in same-gender dyads) and we studied how the effects of the EAT varied depending on gender. Finally, we examined the relationship between participants' perceived intensity of emotions after collaboration and their perception of the interaction with their partner, and also how the EAT can impact this relationship (Question 3).

## Method

### Participants and Design

Sixty participants (32 women and 28 men, mean age = 23.4 years) took part voluntarily in the study. They were randomly assigned to 30 same-gender dyads. Fifteen dyads were randomly assigned to each of the 2 following conditions: (1) experimental (EAT) condition (8 women dyads and 7 men dyads) in which the participant were provided with the Emotion Awareness Tool; (2) control condition (9 women dyads and 6 men dyads) in which they were not provided with the EAT. Group members did not know each other, and everything was done so that they did not see each other before the experiment. Each participant was remunerated 60 Swiss Francs.

### CSCL Environment

DREW (Corbel et al. 2003; see also Lund & Molinari, 2007) was used as the CSCL environment in which the collaborative task had to be performed. Participants were asked to use the argument graph tool (left/blue part of

Figure 1) to construct together a joint map (see the "procedure" section to have a description of the task). In this map, boxes could be linked to each other using two types of links, "+" or "in favor" links and "-" or "against" links. Besides, participants had the possibility to express their opinion "for" or "against" for any boxes (or links) in the map (each participant's opinion appeared in a different color). Boxes for which two opposed opinions have been expressed, appeared in a "crushed" form. During the construction of the joint map, participants could communicate with each other through microphone headsets (their verbal interactions were recorded).

Participants of the experimental condition were asked to self-report and share their emotions to their collaborative partner using the EAT (right/red part of Figure 1). The lower part of the EAT consisted of a list of 10 positive (e.g., engaged, interested, satisfied, relaxed) and 10 negative (e.g., anxious, frustrated, unsatisfied, tired) emotions, each of them referring to a button to click. The upper part of the EAT was dedicated to the display of emotions on which participants clicked. The participants' emotions appeared in the green area, their collaborative partner's emotions in the blue area. Moreover, in both green and blue areas, the current emotion was displayed in a box with a lighter color background, immediately followed by the two previously inputted emotions. Participants could also enter any emotion directly in the lighter green box. Participants were instructed that they were free to self-report their emotions at any time they wanted during interaction. They were however prompted to self-report their initial emotion and a pop-up message appeared 5 minutes after the last inputted emotion to remind them to indicate the emotion they were experiencing at that moment. Participants of the control condition were not provided with the EAT (the screen part corresponding to the EAT was shaded).

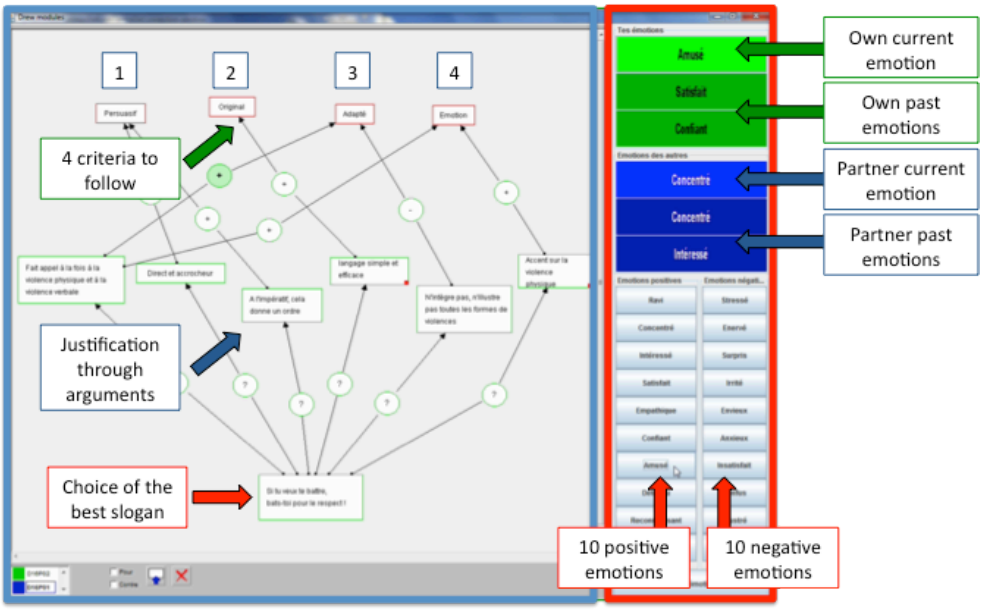


Figure 1. The DREW interface coupled with the EAT.

## Procedure

The members of each dyad were separated in two different rooms. Both peers were in front of computers equipped with (a) webcams, (b) Tobii T120 eye-trackers and (c) BioSemi physiological data acquisition systems (eye-tracking and physiological data will not be the focus of this paper). They could not see each other, and could not use the webcams to communicate with each other at any point of time during the session. The experimental session lasted 140 minutes, and consisted of four phases:

(1) *Introduction* (60 min): Participants were equipped with BioSemi physiological sensors, and eye-tracker calibrations were completed. Training was given to get them familiar with DREW (and with the EAT in the experimental condition).

(2) *Collaborative design task* (40 min): Participants were asked to perform (in dyads) a brainstorming exercise so as to design together a slogan against violence in schools intended for teenagers. During the brainstorming, they drew a joint map, using the DREW argument graph tool, in 3 steps. In Step 1, both partners generated as many boxes of slogan ideas as possible in the map. In Step 2, they were asked to debate and argue slogan ideas depending on four criteria boxes given in the map (persuasive, original, adapted to audience, and emotion). Slogan ideas should be therefore linked to criteria boxes through argument boxes. After debating, peers suppressed the less relevant slogan ideas and improved those remaining. In the last step (Step 3), they were asked to negotiate and find a consensus about the best slogan; the result should appear in a new box entitled "final slogan" at the end of the brainstorming (see Figure 1).

(3) *Post-test questionnaires* (20 min): After collaboration, participants first rated the intensity of their own- and their partner's emotions. The felt intensities of 20 emotions (the same 10 positive and 10 negative emotions than those used in the EAT) were measured on 7-points items (ranging from 1 = "very low or not at all" to 7 = "very high"). They then answered a questionnaire about their perceptions of the interaction they had with their partners. This questionnaire was constructed based on that developed by Buchs et al. (2004), and consisted of 5 groups of questions. In this paper, we only reported the analysis of answers to questions of Group 4 and Group 5. These questions referred to the participants' perceptions of their own- and their partner's activities during collaboration. Seven-point scales (ranging from 1 = "little time" to 7 = "much time") measured how much time participants felt they (or their partner) had spent defending ideas and arguing about them, building up on the other's ideas, comparing their emotions to the other's emotions, communicate on emotions, etc. (see Table 1 for the complete list of items). Finally, three questionnaires were administered to assess participants' emotional characteristics, the Emotional Expressivity Scale (Kring et al., 1994), the Emotional Contagion Scale (Doherty, 1997), and the Emotion Regulation Questionnaire (Gross & John, 2003).

(4) *Debriefing* (20 min): Participants were provided with a video of their group work (including their face and the shared screen), and annotated 10 moments where they felt an emotion (and 10 without emotions).

### Variables

The presence of the EAT (with *vs.* without the EAT) and Gender were the between-subjects factors. The dependent variables were: (a) the participants' ratings of the intensity of their own emotions and their partner's emotions (the 20 emotion items, 10 positive and 10 negative emotions), and (b) the participants' answers to two groups of questions (Groups 4 & 5) measuring their perception of their own- (15 items) and their partner's activity (15 items) during interaction (the "own-activity" and "partner-activity" items were equivalent). They were requested in the perceived interaction questions to rate the frequency with which they – and their partner – provided/imposed their own points of view, defended and argued their ideas, understood their partner's points of view, built up on their partner's ideas, as well as managed emotion during interaction (see Table 1).

## Results

### Q1: Effect of the EAT on Perception of Emotions after Collaboration

Concerning participants' own emotions, results showed that intensity ratings were higher for positive emotions ($M = 4.51$, $SD = 0.84$) than for negative emotions ($M = 1.76$, $SD = 0.68$), $t(1, 59) = 20.07$, $p < .001$, Cohen's $d = 3.64$. The same pattern occurred for the perception of the partner's emotions (positive: $M = 4.41$, $SD = 0.85$; negative: $M = 1.64$, $SD = 0.56$), $t(1, 59) = 21.59$, $p < .001$, Cohen's $d = 3.76$. A series of 2 (EAT) x 2 (Gender participant) ANOVAs were performed on intensity ratings for own/partner positive and negative emotions. The results did not reveal any significant main effects for the factors studied and their interactions.

### Q2: Effect of the EAT on Perception of Interaction with the Partner

Thirty perceived interaction items were used in the analysis (see Table 1). They were submitted to a factorial analysis (FA) with promax rotation. The Cattell Scree test indicated the presence of three factors that accounted for 50.72% of the total variance, namely (a) F1: *to communicate on emotions and adapt to emotions* (27.51%), (b) F2: *to compare emotions and imagine reactions to emotions* (12.52%), (c) F3: *to argue and build on the other's ideas* (10.69%). The items and their factor loading are presented in Table 1. It is noteworthy that F1, F2 and F3 included both "own-activity" and "partner-activity" items; we thus decided to talk about the *activity of the dyad* when presenting the results concerning those factors.

A series of 2 (EAT) x 2 (Gender participant) ANOVAs were performed on the three factor scores. Results showed a significant effect of EAT for Factor 2. Participants reported more time spent by their dyad comparing emotions and imagining reactions to emotions in the EAT condition ($M = 0.35$, $SD = 0.96$) than in the control condition ($M = -0.36$, $SD = 0.84$), $F(1, 53) = 8.60$, $p < .01$, partial $\eta^2 = 0.14$. There was also a significant EAT by Gender interaction for Factor 3, $F(1, 53) = 6.51$, $p = .01$, partial $\eta^2 = 0.11$. Post-hoc tests revealed that women reported spending more time arguing and building on the other's ideas in the EAT condition ($M = 0.50$, $SD = 0.83$) than in the control condition ($M = -0.18$, $SD = 1.06$); this difference was marginally significant, $t(1, 28) = 1.97$, $p = .057$. The reverse pattern occurred for men (EAT: $M = -0.48$, $SD = 0.51$, control: $M = 0.05$, $SD = 1.02$), but this difference was not significant, $t(1, 25) = -1.65$, $p = .11$. Moreover, there was a significant difference between women and men in terms of perceived time spent arguing and building on the other's ideas ($time_{women} > time_{men}$) in the EAT condition, $t(1, 27) = 3.71$, $p < .001$; no significant difference occurred between men and women in the control condition, $t(1, 26) = -0.57$, $p = .57$.

### Q3: Relation between Self-Reported Emotions and Perceptions of Interaction

Correlational analyses were performed to test the relation between the participants' ratings of the intensity of positive/negative emotions after collaboration, and their perceptions of the interaction with their partner (the 3 extracted factors presented in Table 1 were used here). Pearson's correlations were conducted across and within conditions (i.e., EAT and control conditions). The analysis across conditions showed that the perceived intensity of positive emotions after collaboration was positively correlated with the perceived amount of time spent (a) comparing emotions and imagining reactions to emotions (F2: $r = .41$, $p < .05$), (b) arguing and building on the other's ideas (F3: $r = .49$, $p < .05$). These positive correlations were significant only in the EAT condition (F2: $r = 0.43$; F3: $r = 0.58$). In the control condition, the perceived intensity of negative emotions after the interaction was positively correlated with the perceived amount of time spent comparing emotions and imagining reactions to emotions (F2: $r = .65$, $p < .05$).

Table 1. Interaction perception items and their factor loading via FA with promax rotation (pattern matrix)

| | | F1 | F2 | F3 |
|---|---|---|---|---|
| What is the frequency with which *you* (own-activity items) | provided *your* own points of view | | | .64 |
| | defended and argued *your* own ideas | | | .70 |
| | imposed *your* own points of view | | | |
| | challenged *your partner*'s ideas | | | |
| | understood *your partner*'s points of view | | | |
| | built up on *your partner*'s ideas | | | .56 |
| | understood *your partner*'s emotions | | .51 | |
| | communicated on *your partner*'s emotions | .95 | | |
| | adapted *your* behavior to *your partner*'s emotions | .51 | | |
| | understood *your* own emotions | | | |
| | communicated on *your* own emotions | .66 | | |
| | adapted *your* behavior to *your* own emotions | | | |
| | imagined *your partner*'s reactions to *your* emotions | | .85 | |
| | compared *your* emotions to *your partner*'s emotions | | .94 | |
| | appeared able to control *your* own emotions | | .63 | |
| What is the frequency with which *your partner* (partner-activity items) | provided *his/her* own points of view | | | .58 |
| | defended and argue *his/her* own ideas | | | .63 |
| | imposed *his/her* own points of view | | | |
| | challenged *your* ideas | | | |
| | understood *your* points of view | | | .82 |
| | built up on *your* ideas | | | .61 |
| | understood *your* emotions | | | |
| | communicated on *your* emotions | .92 | | |
| | adapted *his/her* behavior to *your* emotions | .53 | | |
| | understood *his/her* own emotions | .69 | | |
| | communicated on *his/her* own emotions | .66 | | |
| | adapted *his/her* behavior to *his/her* own emotions | .57 | | |
| | imagined *your* reaction to *his/her* own emotions | | .63 | |
| | compared *his/her* emotions to *your* emotions | | .72 | |
| | appeared able to control *his/her* own emotions | | | |

*Note*: F1 = to communicate on emotions and adapt to emotions, F2 = to compare emotions and imagine reactions to emotion, F3 = to argue and build upon the other's ideas.

## Discussion and Conclusion

Successful collaborative work requires group members to build a shared understanding (Roschelle & Teasley, 1995) which is contingent upon effective awareness of what their partners know, believe, feel, do and intend to do (Sangin et al., 2011). While recent research on computer-mediated collaboration and CSCL has focused on the effect of the awareness of the partner's knowledge (Dehler et al., 2011; Molinari et al., 2009; Sangin et al., 2011) or activity level (Janssen et al., 2010), little attention has been given on the role of the awareness of the partner's emotions (Eligio et al., 2012). On the one hand, emotions are now recognized as being strongly related to individual and group processes (D'Mello & Graesser, 2012; Van Kleef, 2009). On the other hand, collaboration is challenging at the socio-emotional level (Järvenoja, 2010) since it consists of continuous fluctuations of tension and relaxation between group members who alternate between performing the task and maintaining a good working relationship (Andriessen et al., 2011; Baker et al., 2009). One may therefore expect that the awareness of the partner's emotions can play a determinant role in collaborative work/learning situations as it contributes to adaptive and regulatory social processes.

In this study, an emotion awareness tool (EAT) was developed which provided awareness about the emotions felt by the partner during a remote (computer-mediated) collaborative design task. Our objective was to investigate to which extent the explicit emotional feedback could impact participants' subjective perceptions of their collaborative work experience. With respect to our first question, results showed no effect of the EAT on participants' perceptions of their own emotions and their partner's emotions after collaboration. In other terms, raising emotion awareness between collaborative partners by giving them the possibility to explicitly share their emotions does not seem to influence their perception of emotional states after collaboration. Our second question concerned the effect of the EAT on participants' perceptions of the quality of their interaction with their partner. We also examined the relationship between participants' perception of emotional states after collaboration and their perception of the quality of interaction, and also how the EAT can impact this relation (Question 3). On the one hand, self-reported measures indicated that the EAT stimulated group members to engage in a process of mutual modeling of emotions during interaction – which is a process by which they compared their respective emotions and also anticipated their respective reactions to emotions. Moreover, the perceived amount of time spent on emotion modeling process was positively correlated with the perceived intensity of positive emotions after collaboration in the EAT condition. This is consistent with results found in the study conducted by Eligio et al. (2012) where participants reported experiencing more positive affect after sharing their emotions during computer-mediated collaboration. In contrast, in the condition where participants did not explicitly share their emotions (control condition), the social comparison of emotions was related to negative emotional states after collaboration. On the other hand, it seems that the effect of the EAT on the perceived quality of interaction varied depending on gender. The EAT had a positive effect on the perceived amount of time spent by the dyad confronting and arguing points of view, building up on the other's ideas – or in other words, on the perceived *degree of transactivity* (which has been found to be positively correlated with collaboration outcomes; Weinberger et al. 2007) – but only for women. There was no significant difference in terms of perceived degree of transactivity between women and men in the control condition. Therefore, these results do not suggest any significant effect of emotion awareness on men's perceived degree of transactivity. Finally, we found that the perceived degree of transactivity was significantly correlated with positive emotional states after collaboration, but only in the EAT condition. In the condition where participants explicitly shared their emotions with their partner, the more they reported focusing and contributing to the ideas proposed by their partner, the more they reported positive emotional states after collaboration.

In our study, results support the hypothesis of a beneficial effect of an emotion awareness tool on (perceived) collaboration – but only for dyads of women. This was also the case in the study of Eligio et al. (2012) who found a positive effect of sharing emotions on group performance, but only with women (since men were excluded from their study to avoid the controversy of gender differences). In our study, men who shared their emotions with their partner during interaction reported being engaged in less partner-focused interactions. Previous research (Brody, 2000) showed that compared to women, men are much less likely to display emotions. This can be explained by socio-cultural beliefs that the display of emotions (in particular, negative emotions) is related to less interpersonal power (Ragins & Winkel, 2011). One may thus expect that forcing men to display and share their emotions during a collaborative work could inhibit them from performing the task with their collaborative partner.

To conclude, the present study has potential to enrich our understanding of how emotion awareness influences collaboration processes, and how to design group awareness tools as means of improving emotion awareness between coworkers in CSCL settings. It also provides a first step in exploring the effect of emotion awareness in collaborative tasks including a comparing approach for its gender-specific relevance. As a further step in the analysis, we will examine verbal interaction data (captured by the microphone headsets) so as to give a more reliable insight into the quality of the interaction, and we will also assess the effect of the EAT on group outcomes (e.g., the number of intermediate slogans created by the groups). Additional analyses on eye-tracking and physiological data are also in progress to better understand the effect of the EAT. Finally, one main limitation of the study is the difficulty in disentangling the effect of reflecting upon one's own emotions from the effect of sharing one's emotions with the partner. In order to overcome this limitation, a new experiment is planned that will use an additional control group in which participants will state their own emotions through the EAT but will not have any access to their partner's emotion statements.

## References


Andriessen, J., Baker, M. & Van der Puil, C. (2010). Socio-cognitive tension in collaborative working relations. In Ludvigsen, S. Lund, A., Rasmussen, I. & Säljö, R. (Eds.). *Learning across sites: New tools, infrastructures and practices*. London Routledge. The Learning series.

Brody, L. R. (2000). The socialization of emotion: Display rules, infant temperament, and differentiation. In A. Fischer, (Ed.), *Gender and Emotion* (pp. 24-47). Cambridge: Cambridge University Press.

Buder, J. (2011). Group awareness tools for learning: Current and future directions. *Computers in Human Behavior*, *27*(3), 1114-1117.

Darnon, C., Muller, D., Schrager, S., Pannuzzo, N., & Butera, F. (2006). Mastery and performance goals predict epistemic and relational conflict regulation. *Journal of Educational Psychology, 98*(4), 766-776.

Davis, M. A. (2009). Understanding the relationship between mood and creativity: A meta-analysis. *Organizational Behavior and Human Decision Processes*, *108*(1), 25-38.

Dehler, J., Bodemer, D., Buder, J., & Hesse, F. W. (2011). Guiding knowledge communication in CSCL via group knowledge awareness. *Computers in Human Behavior*, *27*(3), 1068-1078.

Derks, D., Fischer, A. H., & Bos, A. E. R. (2008). The role of emotion in computer- mediated communication: A review. *Computers in Human Behavior*, *24*, 766–785.

D'Mello, S. K. & Graesser, A. C. (2012). Dynamics of affective states during complex learning. *Learning and Instruction*, *22*, 145-157.

Eagly, A. H., & Wood, W. (1991). Explaining sex differences in social behavior: A meta-analytic perspective. *Personality and Social Psychology Bulletin*, *17*, 306-315.

Eligio, U. X., Ainsworth, S. F., & Crook, C. K. (2012). Emotion understanding and performance during computer-supported collaboration. *Computers in Human Behavior*, *28*, 2046-2054.

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1993). *Emotional contagion*. New York: Cambridge University Press.

Järvenoja, H. (2010). *Socially shared regulation of motivation and emotions in collaborative learning* (Doctoral Dissertation). University of Oulu: Acta Univarsitatis Ouluensis.

Järvenoja, H., & Järvelä, S. (2009). Emotion control in collaborative learning situations – Do students regulate emotions evoked from social challenges? *British Journal of Educational Psychology*, *79*(3),463-481.

Kapoor, A, Burleson, W, & Picard, R. W. (2007). Automatic prediction of frustration. *International Journal of Human-Computer Studies*, *65*, 724–736.

Kapur, M. (2009). Productive Failure in mathematical problem solving. *Instructional Science*, *38*(6), 523-550.

Lee, E. J. (2003). Effects of ''gender'' of the computer on informational social influence: the moderating role of task type. *International Journal of Human-Computer Studies,58*(4), 347–362.

Lehman, B., D'Mello, S. K., & Graesser, A. C. (2012). Confusion and Complex Learning during Interactions with Computer Learning Environments. *The Internet and Higher Education*, *15*(3), 184-194.

Linnenbrink-Garcia, L., Rogat, T. K., & Koskey, K. L. K. (2011). Affect and engagement during small group instruction. *Contemporary Educational Psychology*, *36*, 13-24.

Janssen, J., Erkens, G., & Kirschner, P. A. (2010). Group awareness tools: It's what you do with it that matters. *Computers in Human Behavior*. Elsevier.

MacLeod, C. M., Koster, E. H., & Fox, E. (2009). Whither cognitive bias modification research? Commentary on the special section articles. *Journal of Abnormal Psychology*, *118*, 89-99.

McRae, K., Ochsner, K.N., Mauss, I., Gabrieli, J.D.E., Gross, J.J. (2008). Gender differences in emotion regulation: An fMRI study of cognitive reappraisal. *Group Processes and Intergroup Relations*, *11*, 143-162.

Molinari, G., Sangin, M., Dillenbourg, P., & Nüssli, M-A. (2009). Knowledge interdependence with the partner, accuracy of mutual knowledge model and computer-supported collaborative learning. *European Journal of Psychology of Education*, *24*(2), 129-144.

Picard, R. W. (1999). Affective Computing for HCI. Proceedings HCI. Munich: Germany.

Ragins, B. R., & Winkel, D. E. 2011. Navigating the emotional battlefield: Gender, emotion and power in work relationships. *Human Resources Management Review*, *21*, 377-393.

Rime, B., Mesquita, B., Philippot, P., & Boca, S. (1991). Beyond the emotional event: six studies on the social sharing of emotions. *Cognition and Emotion*, *5*, 435-465.

Roschelle, J., & Teasley, S. (1995). The construction of shared knowledge in collaborative problem solving. In O'Malley, C.E., (Ed.), *Computer Supported Collaborative Learning* (pp. 69-97). Springer-Verlag, Heidelberg.

Sangin, M., Molinari, G., Dillenbourg, P., & Nüssli, M-A. (2011). Facilitating peer knowledge modeling: effects of a knowledge awareness tool on collaborative learning outcomes and processes. *Computers in Human Behavior*, *27*(3), 1059-1067.

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information*, *44*(4), 693–727.

Van Kleef, G. A. (2009). How emotions regulate social life: The emotions as social information (EASI) model. *Current Directions in Psychological Science*, *18*, 184-188.

van Knippenberg, D., Kooij-de Bode, J.M. & van Ginkel, W.P. (2010). The interactive effects of mood and trait negative affect in group decision making. *Organization Science*, *21*(3), 731-744.

Weinberger, A., Stegmann, K., & Fischer, F. (2007). Knowledge convergence in collaborative learning: Concepts and assessment. *Learning & Instruction*, *17*, 416-426.