Computer-Supported Work in Partially Distributed and Co-located Teams: The Influence of Mood Feedback

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Abstract. This article examines the influence of mood feedback on different outcomes of teamwork in two different collaborative work environments. Employing a 2 x 2 between-subjects design, mood feedback (present vs. not present) and communication mode (face-to-face vs. video conferencing) were manipulated experimentally. We used a newly developed collaborative communication environment, called EmotiBoard, which is a large vertical interactive screen, with which team members can interact in a face-to-face discussion or as a spatially distributed team. To support teamwork, this tool provides visual feedback of each team member's emotional state. Thirty-five teams comprising 3 persons each (with a confederate in each team) completed three different tasks, measuring mood, performance, subjective workload, and team satisfaction. Results indicated that the evaluation of the other team members' emotional state was more accurate when the mood feedback was presented. In addition, mood feedback influenced team performance positively in the video conference condition and negatively in the face-to-face condition. Furthermore, participants in the video conference condition were more satisfied after task completion than participants in the face-to-face condition. Findings indicate that the mood feedback tool is helpful for teams to gain a more accurate understanding of team members' emotional states in different work situations.

Keywords: virtual teamwork; videoconference; face-to-face; mood; computer-supported cooperative work

1 Introduction

Over the past 20 years, a growing body of literature addressed the role affective states such as mood and emotions play in the workplace [1]. Although the interest in mood

adfa, p. 1, 2011.

and emotion in organizational research is rather young, there is already a considerable base of knowledge indicating the importance of affect in organizations and work teams. The accurate perception and understanding of team members' affective states for example has proved to have a positive influence on team processes and team performance [2]. In consideration of the importance of an accurate understanding of fellow team members' affective states for an effective and satisfactory collaboration in teams, a tool was developed that represents fellow team members' current mood by means of a visual feedback. The visual feedback consists of an avatar that can be presented on a computer screen (for teamwork in distributed teams) or on a large interactive wall (for teamwork in collocated teams). With this study we aimed to evaluate the utility of such a mood feedback in two different teamwork settings – face-to-face teams (FTFT) and partially distributed teams (PDT).

2 Related work

2.1 Mood and Emotions in teamwork

Mood and emotions can be distinguished with regard to their intensity. While moods are feelings of relatively low intensity, emotions are high intensity feelings triggered by certain stimuli [3]. Representing an important factor in every aspect of social communication, the important role of mood and emotions in the domain of organizational teamwork is generally not contested [4]. Various studies have already shown that affect influences human cognition and behavior in problem solving [5], motivation [6], and social behavior [7], and as such also plays a critical role in teamwork. Team members in a positive mood are for example more likely to be helpful, generous and to act with a sense of social responsibility [8]. Furthermore, positive emotions lead to positive relationships and sense of community in teams and hence have an important impact on team processes and team effectiveness [9]. Furthermore, emotional intelligence, defined as the specific ability to understand and manage moods in the self and others [10, 11], was shown to be a central factor for effective leadership in organizations [12], correlating highly with transformational leadership behavior, which is considered as being beneficial for team effectiveness compared to other leadership styles [13]. Emotionally intelligent leaders are leaders who perceive emotions accurately, understand emotions and manage emotions accurately [12]. The accurate perception and understanding of other team members' affective state is hence an important factor for successful leadership behavior. Understanding fellow team member's affective state is however not only important for group leaders but also for members of a team in general [14,2]. Awareness of fellow team members' affective states helps to maintain effective relationships, contributes to better information exchange and decision making in teams and facilitates conflict resolution [2].

2.2 The influence of videoconferencing in (partially) distributed teams

In the context of increasing de-centralization and globalization of work processes, there is a rising demand for organizations to use technologies that enable employees

to communicate and work across long distances [15,16]. The following factors have also contributed significantly to the increasing role that videoconferencing (VC) plays in today's corporate business: time constraints, high travel costs as well as the scarce availability and high cost of specialized human expertise [17,18].

VC is often considered as being equal to face-to-face communication (FTFC) with regard to the outcome of the communication process [19], for example by ensuring the use of meta-communication such as tone of voice and facial expressions. However, there are various aspects in which the two communication modes differ (e.g. body language, distancing, touch etc.). These aspects might become crucial in situations where the understanding of feelings and emotions of the other is important.

Theoretical concepts such as media richness theory [20], social presence theory [21] or telepresence theory [22] have tried to explain advantages and disadvantages of different forms of computer mediated communication compared to FTFC. Previous research has shown that collaboration within distributed teams may have some disadvantage compared to co-located teams [15,16]. This might be due to the loss of specific communicational cues based on the media that is utilized [19]. Eye contact is one example for an important cue for effective interpersonal communication [23] which is difficult to obtain in VC due to the vertical disparity between the camera mounted on the top of the screen and the position of the other person's eyes on the screen [24,25]. Other nonverbal cues such as body language, interpersonal distance or touch [26,27] as well as subtleties of affect expressions and personality appearances [19] are harder to discern in VC compared to FTFC. In this respect, missing nonverbal cues in VC play an especially important role with regard to social interaction, development of relationships and intimate communication [27]. According to Zajonc [28], emotions are a vital part of everyday social communication and are not only transmitted by the verbal channel but by nonverbal cues as well – nonverbal cues might in fact carry the main affective information. This indicates that the VC may impinge on recognition and interpretation of mood and emotions compared to FTFC. Since mood and emotions play an important role in team processes and team functioning [29], VC may not only influence mood detection and recognition among members of a team but also impinge on other factors such as team satisfaction and team performance.

3 The present study

The primary research question of this study addressed the influence of a tool providing visual feedback of each team-member's actual mood on the process and outcome of group work. It was expected that such a mood feedback tool would alleviate the loss of information richness in partially distributed teams (PDT) with regard to emotional aspects of team functioning. It was of particular interest whether such visual feedback would be beneficial in detecting emotional states of other team members and whether this would influence team satisfaction and team performance. In the experimental setup, one of the team members was a confederate who expressed a negative mood throughout task completion. The use of a confederate is a methodological approach of particular interest. The confederate is a specially trained actor who adopts

a certain role in the study (e.g. expressing bad mood and showing withdrawal behavior during a meeting), based on the instruction of the researcher [30,31]. This allows the researcher to manipulate specific experimental conditions, such as to investigate how withdrawal behavior of one team member influences the functioning of a team. In addition, it also reduces the variance of team behavior since confederates will display only trained and fixed behavioral patterns during the testing procedure (e.g., only talking when being directly asked) rather than showing a wide range of behaviors as one would find for randomly recruited team members (e.g. ranging from dominating the group to being silent). A negative mood was chosen for this study because its influence on teamwork was expected to be stronger compared to a positive one. To answer our research question, an experiment was conducted in which 3-person teams (with a confederate in each team) completed three different tasks, either in a FTFT or in a PDT (video conference) situation. During task completion, half of the teams received feedback about the other team members' mood whereas the other half did not. The following hypotheses were formulated: it was expected that teams receiving mood feedback would be more accurate in detecting other team members' mood, that their performance would be higher and that subjective evaluations of team processes (i.e. team climate and team satisfaction) would be more positive compared to teams not receiving a mood feedback. Furthermore, it was also expected that the effect of mood feedback would be more pronounced in the PDT condition than in the FTFT condition.

4 Method

4.1 Participants

Thirty-five teams (comprising three members each) took part in the study. Since one person in each team was a (female) confederate, a total of 70 participants (80% female), aged between 18 and 35 years (M = 21.56, SD = 2.91), were recruited for this study. All participants were students and did not know each other. The gender composition of each team member was at random.

4.2 Experimental design

Employing a 2 x 2 between-subjects design, mood feedback (feedback vs. no feedback) and communication mode (PDT vs. FTFT) were manipulated as independent variables. In the PDT condition, one person of the team (the confederate) was situated in a separate room and could interact with her teammates located in the other room in the form of a video conference setup. In the latter room, the other two team members worked together on a large screen, upon which the image of the third team member was projected using the EmotiBoard (c.f. description below).

4.3 Instruments

Participants' mood was measured twice during the experiment (at the beginning and after task completion) using the Self-Assessment-Manikins (SAM) [32], a non-verbal instrument measuring two distinct dimensions of emotions (valence and arousal) by means of graphic representations of mood in the form of manikins, based on the circumplex model of affect [33]. While arousal refers to the degree of physiological activation of the mood state (e.g. aggression vs. despair), valence is concerned with the degree to which the mood is positive or negative. For the pleasure-displeasure dimension (valence), the five depictions range from a smiling manikin to a frowning manikin. For arousal, the five depictions range from a calm manikin with closed eyes to a wide awake and highly aroused manikin. In addition, participants were asked to rate the mood of their two teammates once after task completion by means of a slightly adapted SAM scale. The instruction was changed from "How much do you feel emotionally aroused at the moment?" to "How much does the other person feel emotionally aroused at the moment?". As indicators of team performance, user behaviour was recorded with an event logger and different aspects of performance, such as task completion time, numbers of user interactions, and error rate, were calculated. Subjective workload was measured by means of the well-established NASA task load index (TLX) [34]. Team satisfaction was measured by five items of the team effectiveness scale [35].

4.4 Materials

A large plexiglass display (1.6 x 1.2 m), suitable for back-projection, served as the main interface for the EmotiBoard, with which users can interact simultaneously, sharing the same application. In our experiment, we used the interactive screen with a Wii-mote for each participant and a regular PC for the remote participant as an input device for task completion. The system provides a visual surface for collaboration by capturing and transmitting pointing device positions and events (i.e. clicking, drag and drop, deleting) between different machines. This setting was inspired by work from Ishii and Kobayashi on the ClearBoard [36]. In addition, a Java library supports the creation of multi-user applications that can be accessed through multiple remote machines at the same time, using multiple types of input devices. In the PDT condition, the video stream of the remote team members was presented on the screen in half transparency, in combination with the application surface for task completion (c.f. fig. 1). In the FTF condition, the application surface for task completion was presented on the screen.

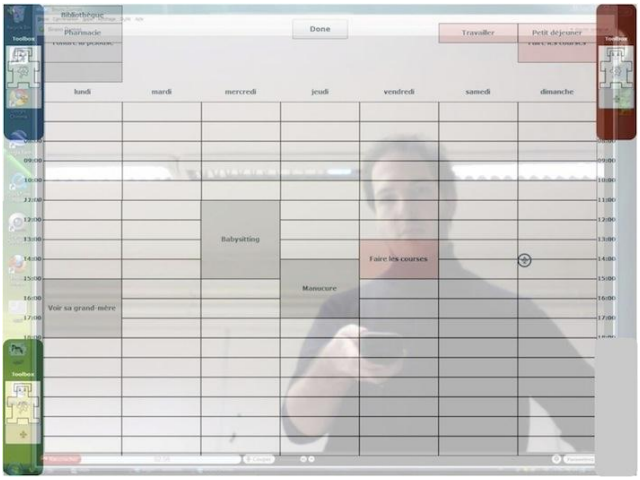

Fig. 1. EmotiBoard screen in PDT condition with remote participant in half transparency.

For the mood feedback, an avatar was created and displayed in each team member's toolbox on the screen throughout the experiment, allowing the other participants to be aware of their co-workers' emotional state (valence and arousal). The mood feedback was based on participant's initial mood rating with the SAM scale. For the design of the mood feedback avatar, SAM-manikins that were used to measure valence (smiling) and arousal (excitation lines) were integrated into one image (c.f. fig. 2). In the no-feedback condition, the toolbox was blank.

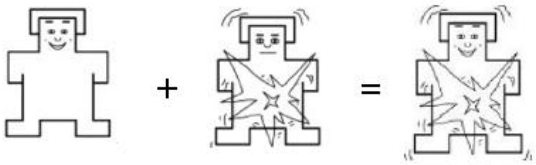

Fig. 2. Combination of SAM-measures of valence and arousal into one feedback image (here with the example of high positive valence and high arousal).

4.5 Team tasks

Three tasks were used in this study, which differed with regard to cognitive demand and communication requirements: (a) a sensori-motor task required the team to connect 100 numbered dots by drawing lines between the dots (1-2, 2-3, etc., c.f. fig. 2), (b) a spatial reasoning task involved placing 12 jigsaw pieces into a figure (c.f. fig. 3),

(c) a coordination and planning task required from the team members to organize the week of a student by placing 126 specific activities into their weekly schedule (planning a week, c.f. fig. 4). For each task, task completion time, number of errors and number of user interactions were recorded.

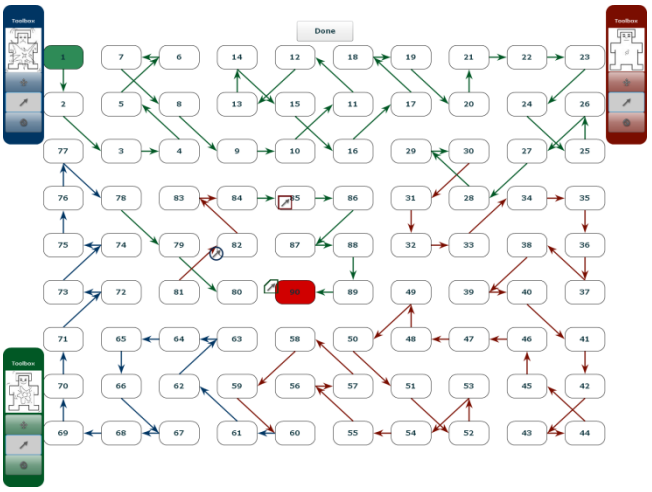

Fig. 3. Screenshot of the EmotiBoard screen for task a).

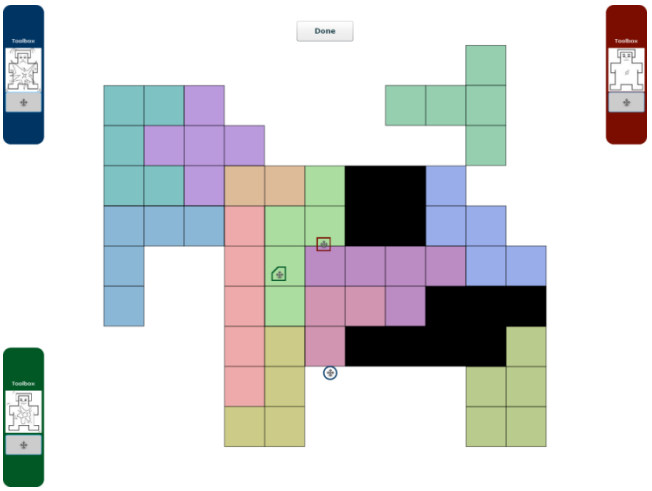

Fig. 4. Screenshot of the EmotiBoard screen for task b).

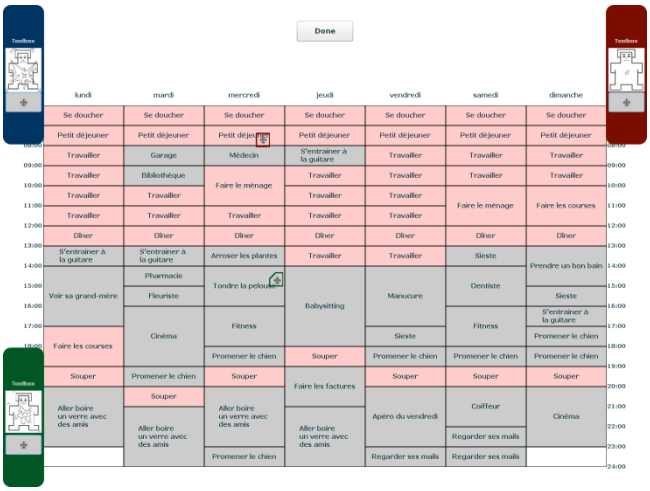

Fig. 5. Screenshot of the EmotiBoard screen for task c).

4.6 Procedure

A (female) confederate was recruited and trained to play a specific role during the completion of group-based tasks. The training was to ensure that the negative mood was expressed convincingly without appearing to be unnatural. The behavior of the confederate involved the refusal to smile throughout the session and to make negative comments about personal feelings and motivation at regular intervals. After introducing the participants to each other, a fake group drawing was organized (for the PDT condition), in which the confederate was always chosen to work in the other room. As a baseline measure, participants were then asked to rate their current mood by completing the PANAS and SAM. After a short explanation of the EmotiBoard, participants were asked to complete an initial training task to become familiar with the system and then completed the three tasks (a), (b) and (c). After that, participants were asked to rate their mood (SAM and PANAS) and the mood of the other team members (SAM). Finally, they completed the NASA TLX, TCI and team satisfaction scale.

4.7 Data analysis

Analysis of co-variance was used to analyse the data. The influence of experience with Wii-motes, age and gender-composition of the group was examined by entering the factors as covariates. Due to the small interclass correlations (all ICC(1) < .05) and since the data was available for each team member, the data was analysed at an individual level [c.f. 37].

5 Results

5.1 Accuracy of mood appraisal of other team-members

To evaluate the influence of the mood display on the accuracy of the rating of other team-member's mood, a difference value was calculated by subtracting the mood-assessment of the other team-members from participants' self-rating of their mood. Figure 6 shows the summarized differences between self-assessment and assessment by others for valence and arousal. Participants in the mood feedback condition were more accurate (mean difference is smaller) with regard to the assessment of others' ratings of valence ($F = 6.28$, $df = 1, 64$, $p < .05$,) and arousal ($F = 24.25$, $df = 1, 64$, $p < .001$) than participants not having mood feedback available.

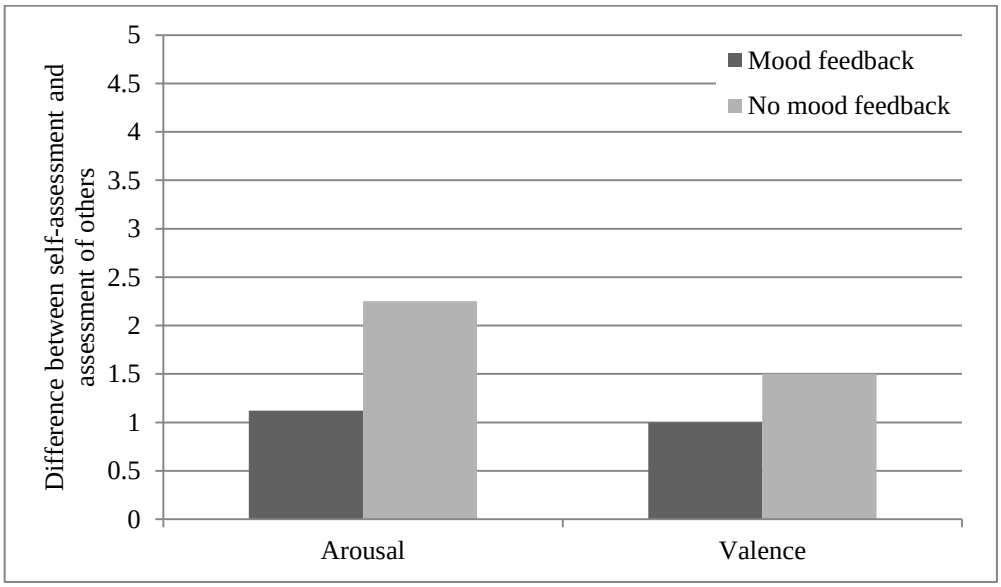

Fig. 6. Difference scores (self-rating – rating of others) for valence and arousal as a function of mood representation.

Although these results indicate that mood feedback had an important influence on the accuracy of the evaluation of others' mood, test participants did underestimate this additional information. Interestingly, 38% of the participants in the mood feedback condition indicated that they did not consider the emotion representation for their assessment of other team members' mood. Only 8% reported to have exclusively considered the emotion representation whereas 54% indicated that they used both, behavioral information (gestures, speech, and facial expressions) as well as the emotion representation to assess the other team members' mood.

With regard to communication mode (c.f. fig. 7), the data indicates a less accurate appraisal of the confederate's mood in the PDT condition for valence and arousal compared to the FTFT condition ($F_{valence} = 5.24$; $df = 1, 64$; $p < .05$; $F_{arousal} = 7.16$, df

= 1, 64; p < .01). Because only the confederate was in remote in the PDT condition, a difference value was calculated exclusively with regard to her self-rating; the two other participants were in the same room and hence communication mode had no influence on the accuracy of their mutual mood ratings. No significant interaction between mood display and communication mode was discovered (all Fs < 1).

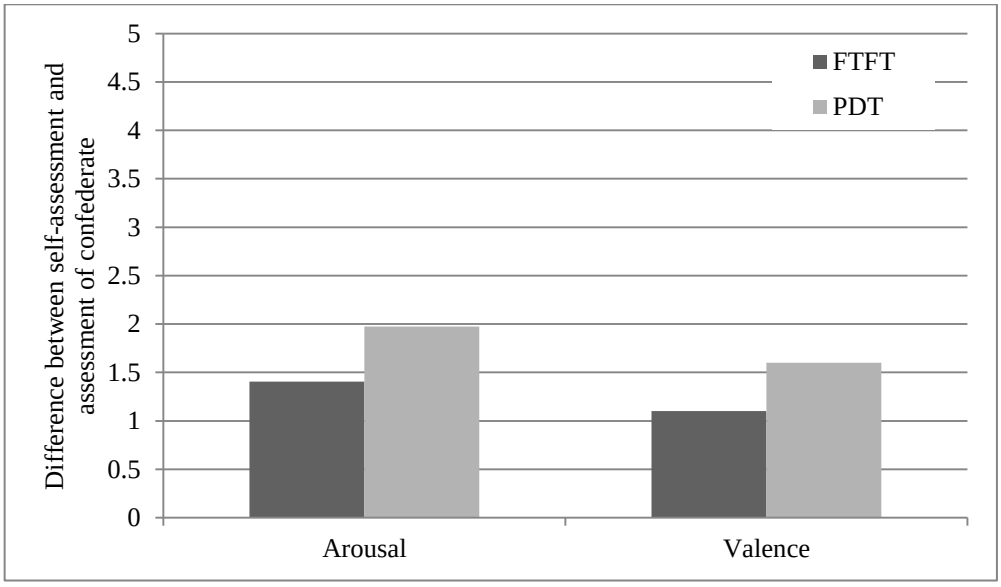

Fig. 7. Difference scores (self-rating of confederate – rating of others) for valence and arousal as a function of communication mode (FTFT: face-to-face team; PDT: partially distributed team).

5.2 Team performance and system management behavior

A marginally significant interaction (communication mode x mood feedback) was found for number of errors (F = 2.89, df = 1, 32, p < .1), indicating an increased error rate in the PDT condition without mood feedback compared to the same condition with mood feedback. In FTFT condition, effect of mood feedback was inversed: more errors occurred with mood feedback compared to teams not receiving a mood feedback (c.f. fig.8). No main effect of mood feedback on measures of performance was found (all Fs < 1).

With regard to communication mode, analysis of the data indicated that participants in the PDT condition committed more errors compared to participants in the FTFT condition (M_{PDT} = 4.88, SD = 4.47; M_{FTFT} = 3.56, SD = 2.44; F = 4.78, df = 1, 32, p < .05). No further effects of communication mode and mood feedback on performance measures (task completion time and number of user interactions) were found to be significant (all Fs < 1).

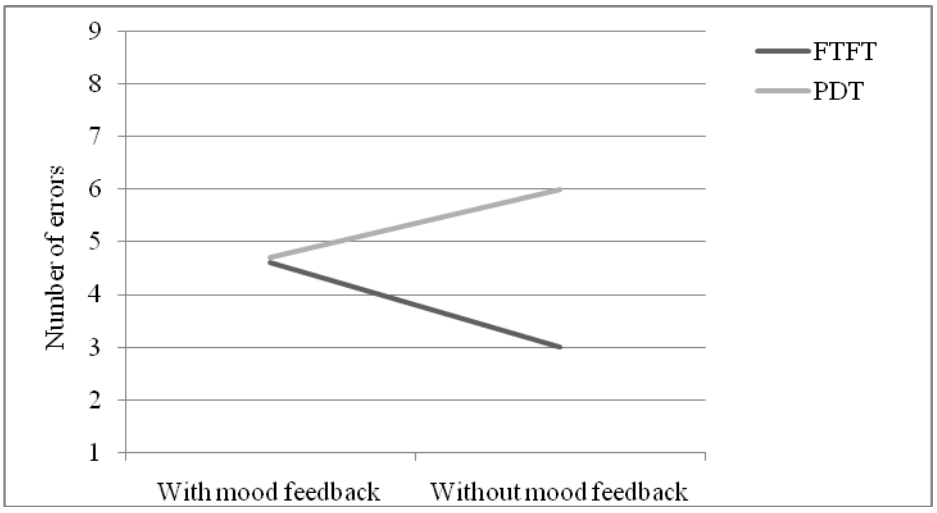

Fig. 8. Interaction between communication mode and mood feedback for number of errors committed during task completion (FTFT: face-to-face team; PDT: partially distributed team).

5.3 Workload

With regard to the different ratings of subjective workload, the analysis revealed a significant interaction (communication mode x mood feedback) for temporal demand (c.f. fig.9). Temporal demand was higher for participants in the PDT condition when no mood feedback was presented, whereas in the FTFT condition, temporal demand was higher when mood representation was available ($F = 9.26$, $df = 1, 64$, $p < .01$). No significant main effect of communication mode and mood feedback and no further interaction were discovered on the other sub dimensions of the NASA TLX (all $Fs < 1$).

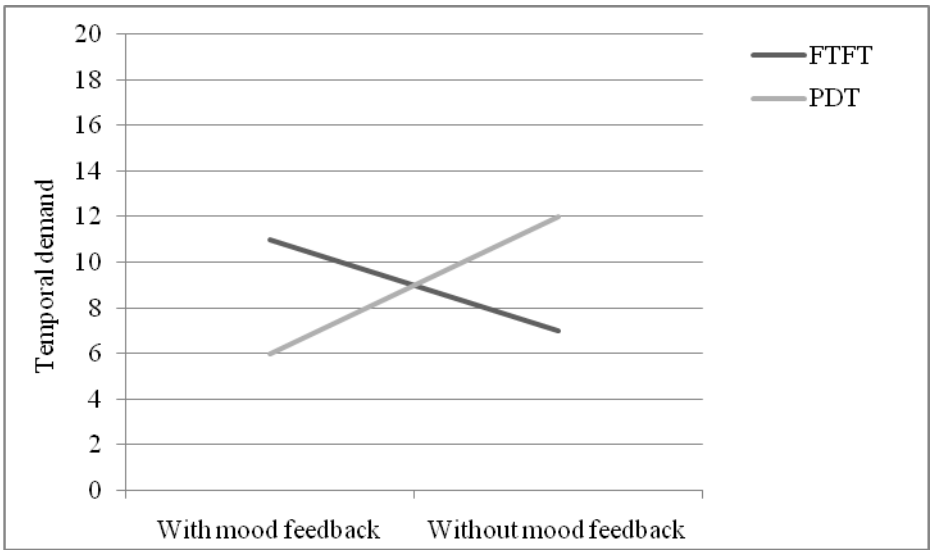

Fig. 9. Interaction between communication mode and mood feedback for temporal demand (FTFT: face-to-face team; PDT: partially distributed team).

5.4 Team climate and team satisfaction

Participants in the PDT condition were more satisfied with teamwork and team processes than participants in the FTFT condition (MPDT = 20.38, SD = 2.60; MFTFT = 18.22, SD = 4.57; $F = 3.98$, $df = 1, 64$, $p < .05$). Furthermore, participants in the PDT condition expressed a stronger preference for working again with the other team members compared to participants in the FTFT condition (MPDT = 3.94, SD = 0.74; MFTFT = 3.25, SD = 1.18; $F = 6.95$, $df = 1, 64$, $p < .05$). Mood feedback showed no effect on team satisfaction ($F < 1$). Furthermore, no significant interaction was found ($F < 1$).

6 Discussion

The main objective of this study was to evaluate the influence of an emotion representation tool in different collaborative work environments. The results indicated a more accurate appraisal of other team members' emotional state when mood feedback was available. This implies that this tool supports teams to gain a more accurate understanding of team members' emotional states in different work situations. Furthermore, appraisal of other team members' mood was less accurate in the PDT condition, indicating that it is more difficult to discern emotions of others in PDT, when less information is available due to the lack of social context cues compared to FTF communication.

Rather unexpected was the finding that almost 40% of test participants indicated that they did not consider the mood feedback for the evaluation of their fellow team

members' mood. This is astonishing since those participants were still more accurate in their mood ratings of others compared to the participants in the condition without mood feedback. It can be assumed hence that they perceived the mood feedback in some unconscious way. It is planned for future research to evaluate whether team members are really not looking at the emotion representation (by means of an eye-tracking study) and why team members think or pretend that they do not consider the information provided by the EmotiBoard.

With regard to measures of performance, the results reported in this study are less clear and caution is advisable when interpreting the results. Although only marginally significant, a statistical trend indicated that teams in the PDT condition committed more errors than teams in the FTFT condition. This might be due to the lack of social context cues in PDT and corroborates previous findings indicating a decrease in performance in teams working remotely compared to FTF teams [15]. However, this difference occurred only if no mood feedback was available. When mood feedback was provided, error rates of teams working together in FTFT and PDT were very similar. This indicates that mood feedback is beneficial in PDT and leads to better performance. In contrast, teams working in the FTFT condition did not benefit from the mood feedback but committed even more errors when a mood feedback was available. This might be due to information overload or distraction, because team members in the FTFT condition, have already plenty of behavioral and non-verbal information about other team members' mood. The additional information on team members' mood provided by the system is largely redundant but commits additional attentional resources. Findings on subjective workload might be helpful to interpret this result. The interaction between mood feedback and communication mode for perceived temporal demand indicates a similar effect pattern as for the error rate: team members in the PDT condition felt more time pressure during task completion when no mood feedback was available whereas team members in the FTFT condition felt more temporal demand when the mood feedback was provided.

Data on team satisfaction indicated that team members working together in the PDT condition were more satisfied with teamwork and expressed a stronger preference for being in this group than team members in the FTF condition. This might be due to the fact that the confederate expressing a highly aroused bad mood was more distant in the PDT condition and hence had a smaller negative influence on measures of team satisfaction. Mood feedback however showed no influence on subjective measures of team satisfaction and team climate. This is somewhat astonishing since it was expected that knowing about other team members' mood would help to build and maintain positive relationships and facilitate conflict resolution [2]. There may be a number of reasons why the anticipated effect did not occur. The study made use of ad-hoc teams (i.e. team members had not known each other), which need some time to go through the typical processes of team building, such as forming relationships and mutual trust. Furthermore, the teams worked together on the tasks for rather a short period of time (M = 21min, SD = 12min). Finally, the team tasks in this study did not have a high potential for conflict. Since it seems that there have not been any conflicts during task completion, mood feedback did not facilitate conflict resolution and therefore could not have had a positive influence on team satisfaction and team

climate. Future research employing more conflict-laden tasks may be needed to demonstrate that mood feedback has an influence on measures of team satisfaction and team climate.

Some limitations with regard to the generalization and interpretation of the results are acknowledged. It is important to note that the results of this study were obtained in a specific experimental setup, in which a confederate was expressing explicitly a negative, highly aroused mood. Although this did not lead, as expected, to high levels of conflict within the teams, the use of a confederate might still have had some influence on the results of the study, e.g. with regard to subjective measures of satisfaction, c.f. section 5.4. It would have been desirable to include also a confederate expressing an explicitly positive mood as well as a control group with no confederate in this study to have a more complete experimental design. Due to time and financial constraints, this was however not possible.

7 Conclusion

Overall, the results of this study indicate the usefulness of the EmotiBoard as a mood feedback tool, because it helped better understand other team members' mood and improved other outcome measures of team work. This is a very promising first result obtained with a tool that is still under development. A new version of the EmotiBoard is currently developed, which will automatically assess team members' mood, based on speech prosody and physiological data (skin conductance, heart rate variability). Future research still needs to determine whether such a tool would also work in a different cultural setting and different application areas (e.g. virtual teamwork, e-learning or online psychotherapy), however studies using a similar tool for self-feedback of affective states (AffectAura, c.f. [38]) or for honest signals in video conferencing [39] hinted already at the usefulness of such an instrument in similar application areas. The findings of this study are encouraging to continue the enhancement of the EmotiBoard to a team support system that automatically detects and represents moods in team work. This is because understanding mood and emotion is especially important within efficient teams, in particular with regard to difficult work situations such as intercultural teamwork [2,4].

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