A Mobile System and Application for Facilitating Emotional Awareness in Knowledge Work Teams

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Abstract

In this paper we present a prototype of a mobile system and application for enhancing emotional awareness in knowledge work teams. The prototype gathers emotional, social and informal information on a group of users explicitly and implicitly. The advantages of using the prototype are expected to be increased emotional awareness within group possibly leading to positive effects on group performance.

1. Introduction

We see knowledge work consisting of the capacity to act in intelligent ways in one's context and environment. Senge [29] suggests that while information implies knowing "about" things, and is received and passed on, knowledge implies knowing "how", thereby giving people the capacity for effective action. Davenport et al. [7] define knowledge work as "the acquisition, creation, packaging, or application of knowledge. Characterized by variety and exception rather than routine, it is performed by professional or technical workers with a high level of skill and expertise."

Consequently, knowledge work includes the creation of knowledge, the application of knowledge, the transmission of knowledge, and the acquisition of knowledge.

McGrath and Hollingshead [26] have proposed that technologies, as they have been applied to groups, can be placed along a dimension of increasing and decreasing richness of social cues. Face-to-face groups have access to a rich variety

of social cues that they can then use to determine the preferences and positions of other group members. On the other hand, computer-mediated groups, do not have access to nonverbal cues, and must rely simply on the written word. That is, computer mediated groups and hence computer mediated group work are low in the richness of social cues.

We propose an application to facilitate emotional awareness in knowledge work groups. Our application enhances emotional awareness in a group by the increasing the richness of informal, non-explicit and non-verbal communication. We expect our application to have beneficial effects on performance in knowledge processes and tasks.

In this article we will first discuss different types of awareness in groups, define emotional awareness, discuss specific problems in knowledge work and knowledge work systems and present an initial system to support increased emotional awareness in knowledge work. The aim is to describe our conceptual standing to the problem and to act as basis for further empirical research on the effects of emotional awareness on group performance.

2. Awareness in Groups

2.1. Group and Social Awareness

There are different types of group awareness some of which are relevant to work-like tasks. According to Greenberg [18], there are several types of group awareness needed for effective collaboration:

- *Workspace awareness* is ``*the up-to-the minute knowledge a person requires about another group member's interaction with a shared workspace if they are to collaborate effectively*".
- ``*Group-structural awareness involves knowledge about such things as people's roles and responsibilities, their positions on an issue, their status, and group processes.*"
- ``*Informal awareness of a work community is basic knowledge about who is around in general (but perhaps out of site), who is*

physically in a room with you, and where people are located relative to you."
- ``*Social awareness is the information that a person maintains about others in a social or conversational context: things like whether another person is paying attention, their emotional state, or their level of interest.*" Other information can be the special skills a co-worker has.

Often in knowledge work situations, awareness of others provides information that is essential for frictionless and effective collaboration. Even though group awareness is taken for granted in face-to-face work, it is rather difficult to maintain in distributed settings. Hence, there is a considerable challenge in designing technology to support the types of group awareness that actually may lead to increased performance or other beneficial effects at work.

2.2. Emotional Awareness and its Effects on Groups

Emotions, moods and sentiments

Emotions are biologically based action dispositions that have an important role in the determination of behavior [e.g. 23]. It is generally agreed that emotions comprise three components: subjective experience (e.g., feeling joyous), expressive behavior (e.g., smiling), and physiological activation (e.g., sympathetic arousal) [see 30].

Motivational state or action tendency and cognitive processing have also been regarded as important constituents or determinants of emotions. According to the motivational model of emotional organization, the different forms of emotional expression are driven by two separate but interactive motivational systems: (a) the behavioral inhibition system (BIS; or aversive system), prototypically expressed by behavioral escape, avoidance, and withdrawal and (b) the behavioral activation system (BAS; or appetitive system), prototypically expressed by behavioral approach and activation [17, 23, 35, 36]. The BIS and BAS underlie the experience of negative emotions and positive emotions, respectively [17], negative emotions including behavioral components of withdrawal and positive emotions a tendency to approach the source of the stimulus [14].

There are two main competing views of emotions. Proponents of the basic distinct emotions argue that emotions, such as anger, fear, sadness, happiness, disgust, and surprise, are present from birth, have distinct adaptive value, and differ in important aspects, such as appraisal, antecedent events, behavioral response, physiology, etc. [e.g. 9]. In contrast, according to a dimensional theory of emotion, emotions are fundamentally similar in most respects, differing only in terms of one or more dimensions. Proponents of the dimensional view have suggested that all emotions can be located in a two-dimensional space, as coordinates of valence and arousal (or bodily activation) [see 23, 24]. The valence dimension reflects the degree to which an affective experience is negative (unpleasant) or positive (pleasant). The arousal dimension indicates the level of activation associated with the emotional experience, and ranges from very excited or energized at one extreme to very calm or sleepy at the other.

Emotions can be assessed with self-report questionnaires about current or past feeling states. Emotions can also be measured with psychophysiological approaches such as heart rate, skin conductance and facial expressions. In our previous studies on emotional responses to media content and mobile technologies we have used a combination of both types of measurement.

We differentiate between three types of categories of affective responses: *emotions, moods and sentiments* [see 5]. Emotions are reactions to events, typically short-lived and directed at a specific target object. Emotions differ from moods in that they have a clear cause or object, are shorter in duration, and are more focused and intense [15].

Moods last longer and act as lenses or filters through which events and objects are appraised. Moods are low intensity, diffuse feeling states that usually do not have a clear antecedent [12], and can be characterized as relatively unstable short-term intra-individual changes that can be also provoked by emotions [32]. As described by Lazarus [25], a mood "is a transient reaction to specific encounters with the environment, one that comes and goes depending on particular conditions" (p. 47).

Sentiments are more persistent, if not permanent attitudes of people they hold towards a certain class of objects [5].

Effects of emotion

Emotions are more likely to change beliefs than moods [31], and are more likely to disrupt activity [25], both of which may have important implications for group performance.

Research has shown that strong emotions can influence group cohesion, commitment, and performance. For example, studying 143 student work-teams, Duffy & Shaw [8] found that intra-group envy led to overall diminished group effectiveness. In detail they proposed that group envy led to greater social loafing, and less cohesiveness and group potency, which was related to lessened group performance.

Effects of mood

Empirical findings indicate that mood can influence the way performance feedback messages are given in organizational settings [13]. Performance feedback messages have been shown to be congruent to the sender's affective state, although the effect is also influenced by communicational experience. Hammer, Stone and Romero [19] have demonstrated that the perceived accuracy of received feedback is strongly influenced by the receiver's mood. The same counts for the acceptability of received feedback. Positive feedback is more accepted by people in a positive mood and negative feedback is more accepted by people in a negative mood [10].

Further, Forgas [11] examined how mood interacts with group discussion to influence group judgments. Forgas induced both negative and positive moods in subjects before a group discussion. The results indicate that group discussion led to higher polarization of positive judgments in the positive mood induction condition. In the negative mood condition the group discussion lessened the polarization of negative judgments.

Effects of sentiments

Sentiments influence group cohesion which in turn may influence group performance. Cohesion is defined as the group members' positive

attraction to the group, that is, "their liking of the group" [22, 27]. Cohesion has also been related to constructs such as team spirit, morale, or "esprit de corps." Cohesion is often investigated as an important contributor to effective group performance [27].

According to a meta-analysis done on cohesion and performance studies there is a positive relationship between cohesiveness and group performance [27]. However, the relationship is mediated by many factors such as the type of group and definitions of cohesion [27].

Emotional Contagion

One mechanism that may transfer and influence emotional awareness in groups is emotional contagion. Emotional contagion refers to the processes whereby the moods and emotions of one individual are transferred to nearby individuals. Contagion is "a relatively automatic and unconscious tendency to "mimic and synchronize facial expressions, vocalizations, postures, and movements with those of another person and, consequently, to converge emotionally" [20, p. 151].

Barsade [3] examined the influence of emotional contagion on team dynamics. The results showed that contagion occurred in both a laboratory study with mood induced by a trained confederate, and a laboratory study in which contagion occurred naturally, with no confederate. Both settings implied that contagion influenced the groups' dynamics. Positive emotional contagion led to improved cooperation, lessened conflicts and higher perceptions of task performance (rated by self, group members and outside judges). Contagion of unpleasant emotions led to the reverse effects.

Emotional awareness

Damasio [6] summarizes the construct of emotional awareness as follows "... *I believe we can separate having feelings from knowing we have feelings. Feelings only become known when they are made conscious*". [6, p 21, italics in original]. Emotional awareness then means being cognizant of one's own or other's feelings.

In face-to-face interaction non-verbal cues are often used to estimate someone else's emotional state. This includes facial expressions (smile, frown, head positions), body movements (hands,

foot tapping) [see 21]. We can also add other non-verbal channels to this such as tone of voice, direction of gaze and other various signals.

We define emotional awareness in knowledge work as consisting of awareness of one's own emotions, moods and sentiments, and awareness of similar constructs at the group level. One of the mechanisms for transmitting emotional awareness between the individual and group level is emotional contagion.

Consequently we see emotional awareness as the group's affective state that arises from the combination of its "bottom-up" components — affective compositional effects — and its "top-down" components — affective context [1]. That is, emotional awareness in groups results from both the combinations of individual level affective factors that group members possess, as well as from group or contextual level factors that define or shape the affective experience of the group. The concept of group emotion has been shown to be reliably recognized by group members and outside raters, both on-site and through video-ratings [2, 4, 33], and has been reliably measured through a variety of statistical techniques.

Our brief literature review shows that there are several possible effects emotional awareness (emotion, mood and sentiments) can have on group performance. While we anticipate that similar effects may arise with the use of our prototype at this point we do not wish to make explicit predictions as to which effects may arise.

2.3. Previous Work in Emotional Awareness and Computing

There are relatively few focused studies on the importance of emotions when computers mediate human-human communication.

Garcia, Favela and Machorro [16] studied visualizations of group emotions in work settings. They used affective icons to convey affect, affective avatars with different emotional expressions and an emotional awareness graph displaying different emotions. The influence of emotional icons (emoticons) was tested with a brief user study in a collaborative use case sketching system with slightly positive results on the group.

Emotional awareness has also been studied in conjunction with Instant Messaging. Sanchez et

al [28] studied mood oriented interfaces for synchronous instant messaging (IM) interaction and found that the use of emotional icons arranged in the valence-arousal emotional space to express one's own emotions and understand the emotions of others was considered useful and understandable by a small number of test users. The user's were given various communication tasks with IM and were asked to use an Affective IM emotive panel, a graphical representation of emoticons in a valence-arousal space based on emotional facial expressions, to pick an emoticon that corresponded with their emotions when sending the message. The receiver of the message read the message and replied, also attaching his own emoticon to the message. Test users reported that the emotional panel was useful and felt it improved their IM communication.

Tran, Yang and Raikundalia [34] studied the roles of various types of awareness in work settings. They investigated awareness of multiple concurrent conversations, presence awareness of a group conversation and visibility of moment-to-moment listeners and viewers in IM in their study. They also used emotional icons as part of their studies but did not directly test their effects. However, it is evident that emoticons are useful or liked by users when doing instant messaging. This can be seen in the adoption of emoticon functionalities in widely used real-life IM applications by Yahoo! and Microsoft.

While there have been various studies in the role of emotions in working groups we found virtually no work in the use of emotional awareness tools in mobile contexts of knowledge work teams.

3. Use Scenario and System Design

3.1. Challenges for Mobile Knowledge Work Systems

The use of computer-mediated communication and information technologies presents challenges for work practices. These included adopting new forms of interpersonal interaction (e.g., email and instant messaging), new information exchange practices (e.g., depositing information online), and new timings (e.g., working asynchronously) and locations (e.g., working on

the move with mobile devices) of work interactions.

Collaborative knowledge work teams can be characterized as teams that work in non-routine, non-linear transformation processes, where team members possess a high variety of skills and diverse technical and scientific knowledge. Knowledge workers deal with uncertain tasks and situations, potentially very diverse team members, unique group characteristics, and varying characteristics of the larger organization [37]. The transformation processes involves complex team dynamics and work processes which are difficult to analyze and control. Typical problems within collaborative virtual teams are misunderstandings, lack of visibility of actions, contacting issues, time zones and general accessibility [37].

Some of these problems in technology mediated knowledge work may be related to the lack of emotional awareness within groups. From one point of view the problem may then be the lack of richness in social cues compared to face-to-face interactions when working.

One possible solution to the social cues richness problems may be systems that are able to capture, transmit and represent rich non-verbal information – such as emotions and moods - within a group in technology mediated knowledge work.

3.2. Supporting General Knowledge Work Processes

Knowledge work tasks can roughly be classified to *job specific tasks* and *general processes* [see 37]. Job-specific tasks differ greatly as a function of the type of work. Examples are preparing a budget, analyzing results in terms of estimated and actual costs, planning and scheduling a project, eliciting and documenting system requirements, and writing applications software. There are also many general processes when working. General processes can be such as goal setting, communication, updates, group cohesion and synchrony maintenance and informal group communication and coordination.

"Mobile" knowledge work differs mostly from "normal" knowledge work in that it takes place in distributed settings with the use of mobile technologies. Mobile knowledge work can be

mostly mobile such as when a person is communicating with others and accessing files on the field while conducting work tasks. Mobile knowledge work is naturally intertwined with non-mobile knowledge work as people move in and out of their offices. Mobile technologies for knowledge work also mix with desktop computing environments as workers also carry their mobile phones to the office.

Our use scenario is enhancing general communication processes of knowledge work teams. We feel that general communication and coordination processes of knowledge work vs. task-focused processes are not well supported by current technologies. Especially emotional, social and informal awareness are not addressed in a coherent manner. Demands of mobility are not well addressed either.

In short we propose a system in which various data is collected from the status of single users and transmitted to other users to an easy-to-use mobile application. The application supports better awareness of others´ emotional states, social context and other not-strictly work-task dependent matters. The application includes a communication tool (like IM), a tool to report one's emotional state and contextual information (as a contextual status message) and a tool to represent various emotional states on the user interface.

Our initial and broad target group is knowledge workers involved in virtual, distributed teams with the need for emotional, social and informal awareness. Table 1 summarizes the expected benefits from the use of our system. It addresses both potential benefits of increased emotional awareness as well as informal and social awareness. Our main focus is on emotional awareness but it may be intertwined with informal and social awareness. We also would like to contrast the potential influence of emotional awareness with informal and social awareness to be able to indicate potential benefits for knowledge work due only to emotional awareness increases.

We will define the types of knowledge work tasks most benefiting from the use of our system after user studies. Of course one could imagine a group level creative task (designing a website and its content) or a routine task (language checking and proofreading a document) and speculate how emotions would play a role in

each type of task. It may be that emotions would play a more important role in a creative task vs. a routine task but without user data we do not wish to make such predictions.

Table 1. Benefits of emotional awareness systems for knowledge work.

Level/type of benefit	Increased emotional awareness	Increased informal and social awareness
Individual	-Better knowledge of the emotional and mood states of other group members -Perhaps better awareness of personal emotional states	-Better knowledge of other's locations tasks, status and other facts. -Possibly better personal situation awareness.
Group	-Improving communication processes within the group, for instance fewer misunderstandings and breaks in communication -Increased trust and cohesion in group -Perhaps lowering the threshold of information sharing within group -Perhaps facilitating new idea creation and elaboration -Perhaps more "intelligent" group actions over time based on extra emotional information of group members	-Improving social presence. -Enhancing group awareness (who is doing what), -Increased trust, cohesion and coordination

In Table 1 most of the assumed benefits of using our system occur at the group level rather than at the individual level. While an individual gains better understanding of group emotions and moods the benefits may be indirect and reflected in the consequent communication processes, information sharing, creative actions and other types of behavior within the group over time.

With regard to verifying the benefits in Table 1 we will use a combination of experiments and field studies. In experiments the emotional states of users can be validated with the use of

psychophysiological techniques in addition to questionnaires.

4. Prototype System and Application

Our first prototype application and system constitutes of a JAVA based application running in a mobile phone. The mobile application is a J2ME MIDIlet that targets MIDP2 2.0 and CLDC 1.0. It facilitates text-based group communication while also showing a graphical representation of various cues about the group's status.

The group status is collected by both self-report questions and sensors. There is a simple five scale questionnaire for emotion. The questions and their interpretation within the system are based on the valence-arousal framework of emotion defined in the beginning of this article.

Arousal describes bodily activation states from excited (high arousal) to sleepy (low arousal). Valence defines emotional states in terms of pleasantness (positive valence) and unpleasantness (negative valence).

The emotional information gathered by our system can be used to infer group emotion and mood states and perhaps sentiments. Of course one of the drawbacks of our system is that the user has to use his or her personal judgment in determining what type of group emotion the system is representing. At the current level of development of our system we have not implemented more explicit or better interpreted representations of group emotion. As we have no user data it is not possible to evaluate how well users are able to understand and use the emotional representations offered by the system.

Partly to demonstrate the possibility to add more questions and more complex visualizations of different experiential states to the system we also added a five scale question about experienced stress level. Stress level is used in our initial prototype as one example of different metrics that could be gathered and combined by our system. In the future we can use psychophysiological sensors to gather experiential data more implicitly.

The answers to the emotion and stress questions can be prompted by the system administrators to facilitate the continuous input of experiential

states to the system. Sensors are used to infer various other types of information to create more informal awareness within the group.

Different sensors can be attached via Bluetooth or they can be located in the phone itself. The application is a data collection and visualization system implemented on top of a UI library. The application provides various predefined visualizations with changeable parameters. Group and individual user status can hence be easily mapped in real-time to visualization parameters to change the appearance of the application to the user.

Other types of user input to the system are status message and instant messaging. Status message is a user typed short text description of his or her status relevant to work. The status message acts as a user profile and is visible to other users. The message is permanent until the user changes it. Instant messaging on the other hand allows real-time communication between group members.

The system also collects nearby Bluetooth devices and records short clips of ambient sound to establish information about the context of use. Location data is also used based on pre-set Bluetooth beacons. In the case of phones with the Symbian operating system cell-id information can also be accessed to provide location information.

Figure 1 gives an example of the visualization of the system using the navigation. Each group member of a knowledge work team is visualized as a "planet" in an orbit. Pictures A, B and C in Figure 1 represent a view on emotion of given users, marked by the "Emotion" sheet being highlighted in the pictures. Here emotional information is visualized per each user. The user of the phone is always on the center of the picture, indicated by "me". The other users are formed around the phone user.

The larger the size of a "planet" the more stress a user is experiencing. Colors are used to illuminate emotional questionnaires sent to users to verify their emotional or other experiential states. Blue represents negative valence and red positive valence. Arousal level is visualized by the amount of fill in the planet. Low fill indicates low arousal level and high fill level high arousal.

The proximity of individual planets in a cluster of users is calculated as averages of the different levels of emotional and experiential information. Hence, in Figure 1 picture B, for instance one can see that user "Kari" is very stressed (large planet size), has negative emotional valence (blue color of planet) and is very aroused (the planet has a high fill level).

Pictures D, E and F in Figure 1 represent the contextual information acquired by the system. In this sheet the proximity of the planets represents the geometric distance between group members relative to the user in the middle. The dots around each planet indicate the number of Bluetooth devices. An anchor visualization represents the proximity to the user's Bluetooth-enabled tabletop PC in the office or a Bluetooth sensor in the office room. The fill level of the planet and the color represent ambient sound level and user activity. Status message and more detailed information on the surrounding Bluetooth devices can be seen by the individual user details, (Pictures E and F in Figure 1). A green person figure on the other hand stands for proximity to a known person's Bluetooth enabled mobile phone. A black mobile phone indicated an unknown person's Bluetooth enabled mobile phone while a diamond represents any other Bluetooth device.
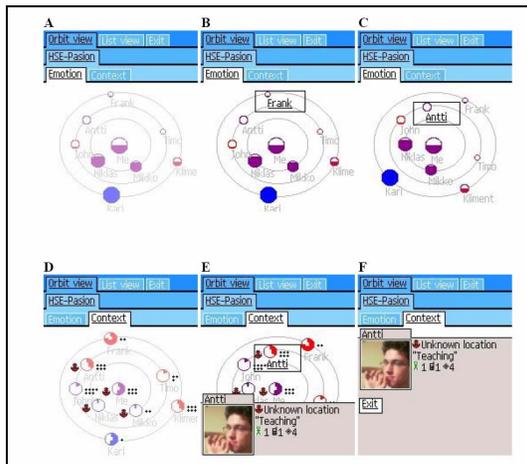

Figure 1. Visualization of the application. Pictures A, B and C represent the emotional view on a group of users. Pictures D, E and F represent the view on contextual information of the group.

Our prototype system facilitates emotional awareness in several ways. First, it gives a reading of one's own emotional state regarding valence and arousal. Secondly, it gives emotional readings of other group members either individually or as an aggregate value. Third, the system displays the emotional information of oneself in the middle in relation to others. The closer another person is to you on the orbit-visualization the more similar she or he is to you emotionally and experientially. Further, the system transmits various other types of information such as self-report status messages as well as information about each user's context and location.

Based on the representations of emotion and context the users can infer a number of things. The information can be used to decide how or when to contact a particular person to ask a question. One can also do social comparisons on the similarity of personal experiential states to those of others or the group aggregate. One may better understand the reasons for a certain person to use a certain type of communication style or type of language (the person may be highly aroused and in negative valence). The experiential status of the group when performing a task can also be observed (everyone is aroused but exhibit positive valence so a challenging task must be going well).

5. Discussion

In our first prototype the gathering of emotion data is dependent on users answering explicit questions about their emotional states. This is problematic. Prompting users to answer such questions too often may be frustrating and divert their attention from the task at hand. However, in later prototypes we wish to be able to address this problem by employing more implicit methods of emotional data collection (such as Bluetooth enabled psychophysiological sensors) or by optimizing the frequency (for instance once an hour at maximum) of emotional explicit data collection.

Another major future challenge for our work is to identify tasks that most benefit from the use of our system. After identifying the tasks we can redesign our system to support them and optimize the use of emotional awareness to fit the purpose. We hope that our initial emphasis on general communication processes across several types of tasks in knowledge work teams

will produce results that help to focus our work further.

There may also be challenges in the area of privacy when using our system. For instance, we hypothesize that no single user would wish to publicly transmit her emotional information. To work around problems such as these we use only aggregated group level emotional visualizations where single user's emotional state is not easily detected.

Despite the obvious challenges we feel that users will benefit from the use of our system by gaining a more holistic view of the experiential state of the group they are working with. Our rationale is to enable users to transmit and receive enriched social cues to enhance their communication processes while working. The intrusiveness, resolution and accuracy of gathering the emotional information as well as the understandability of visual representations of emotions and moods are naturally critical issues. We also feel we are breaking new ground in the development of specifically mobile emotional awareness tools for distributed knowledge work teams.

In the future we will conduct basic usability tests of our system to refine the prototype. We will then test the refined application prototype in simulated and real-life work settings. The research shall focus both on general questions related to tasks that benefit most from increased social cues and emotional awareness as well as on more specific effects of the use of our system on group cohesion, group trust and perceived task performance.

Acknowledgements

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