Happy or Moody? Why so?

Monitoring Daily Routines at Work and Inferring Their Influence on Mood

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ABSTRACT
Technological advancements afford monitoring domains of people's behavior more precisely than a human observer is able to, allowing health-related sciences to benefit in various ways. We aim to employ technology to acquire more detailed information about workers' behavior and to find its correlation with mood states. In current literature, daily mood variation and its determinants are often examined but solely relying on self-rating questionnaires for reporting activities. By exploiting technology to monitor individuals' daily routines at work, we attempt to find precursors of mood states and to create persuasive interventions in order to improve workers' well-being.

Author Keywords
Diurnal variations in mood, monitoring behavioral patterns, mood in workers.

General Terms
Design, Experimentation, Human Factors, Performance, Theory.

INTRODUCTION
Advancements in technology have had a strong influence on a number of scientific disciplines, enabling their accelerated development. In particular, the field of sensors supported the development of smart environments capable of recognizing activities and inferring behavioral patterns of people. In conjunction with recently improved means for measuring various physiological and psychological parameters, these advancements have opened the door for many health-related sciences (e.g. medicine, psychology, psychiatry) that can benefit in large number of ways. Smart home technologies, bio sensors and information networks created together a new paradigm called pervasive health. The goal is to empower health-related sciences by providing relevant data about health problems, aiming to improve diagnosis, afford higher quality of life for people and extend the theoretical knowledge. The technology provides more precise insight into domains difficult or even impossible to be monitored by a human observer. For example, by using RFID-based indoor localization system in a recent study, Kearns et al. [15] correlated the level of wandering in moving patterns and the degree of cognitive impairment. Their design is a foundation for the preventative system that can detect early stages of dementia.

In a similar way, we aim to employ the technology to acquire more precise information about workers' behavior in order to discover new parameters relevant to mood variations. In particular, we focus on monitoring researchers, whose job is considered as cognitively intensive including various types of tasks such as writing or reviewing papers, conducting experiments, having meetings and other activities that may affect mood variations. A number of clinical studies addressed assessing mood and affects regarding circadian rhythms [7] [13] or time of the day [3] [5] [6]. Other studies were focused on the concrete determinants such as the current activities [1], the type of environment [19], the quality of sleep [2] and social interactions [4]. The majority of studies still apply self-reporting approach to infer subject's current mood but there are also works (e.g. [8], [9]) that are taking the advantage of the significant advancements which are made in automated analysis and recognition of human affects [10]. However, all the current studies addressing determinants of daily mood variability rely on self-administered questionnaires to infer people's activities. This approach has considerable disadvantages: (i) in comparison to monitoring the activities by using technology, humans cannot categorize the past actions and their duration in such precise way or even could be incapable to notice some "invisible" factors (for instance, the aforementioned case of moving patterns); (ii) being subjective, individuals are prone to neglect certain parameters that influence their mood or to overestimate other ones. For example, despite the commonly held conception that weather has a strong influence on mood, the average effect of weather is very small in people's day-to-day mood [16].

We attempt to exploit technological advancements to uncover correlations between mood states and daily routines – activities and social interactions at work. Our design monitors knowledge workers at their working place in an unobtrusive manner that does not affect their behavioral patterns. Moreover, we aim to find possible precursors of both good and bad mood and to design persuasive interventions to improve workers' well-being.

Not only mood is an important part of psychological and general well-being, but it is also a factor that has the impact on labor costs. In a study in [17], US workers with depressed mood reported much more Lost Productive Time (LPT) than those without depression (mean 5.6h/week vs.

1.5h/week respectively), which costs employers an estimated $44 billion per year in LPT. Furthermore, mood and emotions at work are related to overall job satisfaction [18]. Positive affects (PA) and negative affects (NA) during work time influence overall job attitude and according to [18] it is a phenomenon worthy of investigation.

The rest of the paper is organized as follows. The next section reviews the most relevant work. The third section describes our approach to monitoring daily routines of knowledge workers and inferring their mood. Lastly, we draw the main conclusions.

RELATED WORK

Mood and its variations during the day were the subject of a number of research initiatives in psychology, sociology, telecommunications and other sciences. Diurnal variations, meaning fluctuations that occur during each day, were often examined as a function of time but many studies aimed to find factors that influence daily mood variability such as social interactions, drugs intake, the type of environment, the quality of sleep, or combinations of more factors.

Clinical self-reporting of mood

Focusing only on time of day as a determinant of diurnal variations, Rubbins et al. [3] investigated patterns of depressed mood periods in normal subjects. In the experiments, 105 undergraduate students were examined and assessed by self-administered psychological diary for mood evaluation. The results showed mood swings in eighty-four percent of the days that were reported as depressed. The peak of bad mood was usually in the evening. Individuals who reported days of constant depressed mood emphasized higher levels of physical symptoms and less pleasure in social interactions. In the similar line, the circadian rhythm of positive affect (PA) and negative affect (NA) were examined in [7]. College students (196 subjects) were completing a mood-rating form seven times a day for one week. The authors reported the existence of diurnal variations in PA but not in NA. They found all components of PA to rise sharply from early morning until noon, remaining constant until 9pm and then to fall rapidly. Thayer [5] analyzed the perception of problems, optimism and associated feelings as a function of time but included the influence of moderate exercise as well. In the experiments self-rating questionnaires were used at fixed times of day. The personal problems were considered more serious at mid to late afternoon than at late morning and after the walk there were periods of higher energetic arousal. Optimism and associated feelings were perceived consistently with the problems. The perceptions of energy and mood were also explored by Wood et al [6]. Diurnal variations in perceptions of physical and mental energy (“vigour”) were evaluated by visual analogue scales. The results showed higher energy levels and also higher levels of PA in the morning between 10.00h and 12.00h. In the experimental group that included undergraduates energy highs are evidenced in the evenings as well.

Volkers et al [2] claim that it is not possible to clearly infer how mood states are related to time of the day since conflicting findings were reported about the timing of mood highs and lows and the pattern of variations during the day. The authors emphasized the sleep quality as one of the factors identified in clinical studies related to disturbances of mood. Subjective sleep quality was assessed every morning by a brief self-rating questionnaire while the adjusted version of the profile of mood states served for the evaluation of the mood after awakening and during morning, afternoon and evening. Sleep quality was positively correlated with vigour after awakening, negatively with fatigue after awakening and during the morning, and negatively with anger after awakening. The authors claim that additional analyses are needed to take into account the influences of work and leisure time activities. Also examining determinants of daily mood variability, Stone et al [1] included in their experiments ninety-four participants that completed a diary every 15 min for 1 day while subjects’ mood activities and locations are assessed. They discovered diurnal cycles for several moods, activities and locations and managed to correlate most moods with certain activities and locations. The study, described in [4], investigated how social interactions are correlated with NA and PA. Both mood and assessment of social interactions were reported using structured diaries that subjects completed three times daily for four weeks. The authors reported positive correlations between PA and fun/active and necessary/informational types of social interaction and between NA and arguing/confronting and receiving help/support. No evidence found about the relation between providing help/support and NA or PA.

Automated mood analysis

The aforementioned studies rely on self-reporting of mood and behavioral/environmental factors. However, numerous studies have addressed the goal of automated analysis and recognition of human affects by using technology. For example, Hasler et al. [8] used the Electronically Activated Recorder (EAR) to follow daily variability in behavior associated with PA and NA. The device is based on recording ambient sounds from the environment that are further coded for different behaviors. Activities associated with PA (e.g. socializing, laughing and singing) varied according to a sinusoidal 24h rhythm centered around participants’ average wake time, while that was not the case for activities usually associated with NA (e.g. arguing and sighing). In addition to audio, significant results are achieved in recent years in the field of machine understanding human affective behavior by using information from video sensors or the fusion with audio. Zeng et al. [10] provided a comprehensive survey on recent advances in human affect recognition.

On the other hand, Fishbah et al. [9] employed technology to analyze informal social networks in companies, aiming to increase employees’ productivity. The approach was based on using so-called Social Badge developed by MIT

Media Lab, capable of monitoring the geographic position, direction of movement and speed, interaction and mood. The authors used Social Badge in combination with social network analysis methods in order to determine subject's communication behavior and to reconstruct the social network.

However, to the best of our knowledge in the current literature there is no work that exploits the technology to monitor various parameters and the impact on influencing an individual's mood. The novelty of our study lies in using technological advancements to uncover critical correlations between mood states and daily activities and social interactions at work.

OUR APPROACH

We designed a framework for monitoring daily routines and the parameters that may influence individuals' mood during working hours. The goal is to find correlation between daily routines and mood (Fig.1). The technology we developed is intended to monitor the external factors, while to correlate these factors with the actual mood levels, we use questionnaires. This section describes both components of our approach.

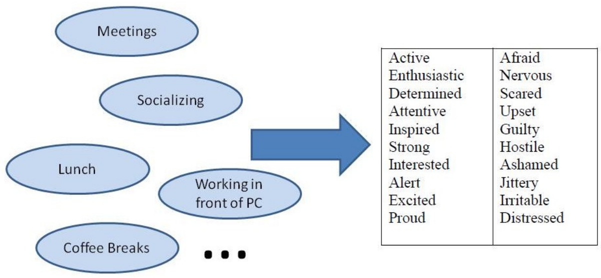

Figure 1. Daily patterns at work and mood states.

Monitoring daily routines during work time

From clinical studies we identified the factors that affect mood such as social interactions, location and activities in general. In comparison to previous studies our approach exploits the technology in order to monitor the parameters more precisely and to mitigate subjectiveness that is inevitable in self-administered psychological questionnaires [21].

An important requirement for the monitoring system in order to provide objective information is unobtrusiveness and invisibility from the user's perspective. Therefore, we opted to use solely mobile phone as it is widely accepted device. Cellular phone is assumed to be omnipresent and it is commonly used by knowledge workers; thus experiments will not interfere with their habits as they usually do in the case of using additional sensors. The challenge is to allow monitoring of workers' routines solely by employing a mobile phone. In the following we explain the details of our method.

Location

Diurnal changes in most moods are strongly associated with activities and locations, that is, the type of environment [1] [2]. Therefore, we found location to be a highly significant parameter for following daily routines that influence subjects' mood as it often discovers activities as well. Considering that our focus is monitoring knowledge workers, we defined the following set of activities/locations important for monitoring:

- Working (sitting in front of PC or at the desk)
- Socializing (coffee rooms, balconies, smoking areas)
- Meetings (meeting rooms)
- Lunch (cafeteria, kitchen or similar)
- Being out of the work place

Since GPS does not work in indoor environments and dedicated localization systems require specialized hardware we needed to find another method for indoor positioning that is accurate enough for the intended application and can be used in a mobile phone. As an effective solution, we utilize our indoor localization system based on FM radio [25] that is convenient for installation in various environments and applicable for mobile phones that have FM radio receiver. The median accuracy of the system is around 1m which is enough not only to distinguish between different rooms (coffee rooms, smoking areas, meeting rooms and so on) but to localize subjects at their working desks or in other parts of rooms. Moreover, it should recognize when two or more individuals (that have mobile units) are close-by which provides information for social interaction detection.

Sound Interaction

Microphone, as a part of every mobile phone and a useful sensor, is still not exploited enough in context-aware applications [20]. In our design, it is used for speech recognition which in conjunction with the location can describe the type of social interaction (e.g. two persons alternately speaking). In a study of diurnal patterns [3] less pleasure in social interactions is identified as a precursor for depressed mood while according to [9] extraversion correlates positively with active participation in personal interaction.

Body movements

Accelerometers are readily available in today's mobile phones, usually embedded for their role in user interfaces [12]. It is a technology already extensively explored for determining the user's activities. Localization and speech recognition are insufficient for categorization of all activities that we intended to monitor for inferring worker's daily routines. Therefore, we included the data from accelerometers to detect periods of walking, running, sitting and standing.

Sleep quality

In clinical studies sleep quality is identified as one of the factors related to disturbances of mood [2]. Even intuitively, many individuals associate their mood with the number of hours they slept or the quality of sleep. In [2], the study in the relationship between subjective sleep quality and diurnal changes in mood, discovered stable daily patterns in vigour and fatigue (while not in depression, anger and tension). Bovin et al. [13] showed that changes in the timing of the sleep-wake cycle can drastically affect mood of the subsequent day. Although significant results are achieved in the field of sleep quality detection by using microphone on mobile phone [11] or accelerometers [14], we decided to use self-rating questionnaire for two reasons. Firstly, obliging subjects to bring their mobile phones with them during night in addition to work time would intrude on their habits thus influencing the authenticity of the results. Secondly, the way in which subjects perceive their sleep i.e. their subjectiveness is suggested to be of high relevance for their mood of the following day [2].

Summary

By exploring the changes in daily routines the goal is to determine the variance in people's day to day mood. The correlation will be explored by using machine learning algorithms, targeting the influence assessment of monitored factors on workers' mood. However, this should be done separately for each of employees by personalizing the results, since one factor could provoke bad mood with one subject while having less influence for another. When distinguishing between day to day routines, assessing the changes in addition to categorization of the activities, special attention will be placed on the duration of each activity. For example, how much time one spends at his/her desk, in meetings, out of the work place, in socializing and so on.

The next section describes the method that we apply for determining employees' mood.

Inferring mood

The Profile of Mood States (POMS) is a well-established multi-dimensional mood scale used extensively to follow fluctuations in affect over time. The short form of this scale, proposed and validated by Curran et al. [22], was selected for this study since it is faster to complete by participants when repeated measures are requested over a day. Participants rate the way they felt at three specific times of the day (morning, afternoon and evening) on a scale of 0-4.

The International Positive and Negative Affectivity Schedule (PANAS) Short Form is another cross-culturally validated measure of emotional states proposed by Thompson [23], which consists of two independent 5-item adjectival rating scales. We aske our participants to rate their feelings of positive affect (PA) and negative affect (NA) three times a day (morning, afternoon and evening) on each of these adjectives on a scale from 1 to 5.

Online versions of the two questionnaires, running on mobile phone were prepared and triggered at about 8.00 am, 13.00 pm and 18.00 pm each day over a two weeks' period. The questionnaire set administered at 8.00 am included an initial question investigating the quality of sleep experienced by the participant the night before ('How did you sleep tonight?' with possible answers 'Well' or 'Not well').

In addition we ask participants to complete each evening the Daily Stress Inventory (Brantley & Jones, [24]), to get more precise information regarding possible stressful events experienced during their working day. Five subscales can be derived from the DSI: Interpersonal Problems, Environmental Hassles, Cognitive Stressors, Personal Competency, and Varied Stressors. We also ask participants to briefly report any particular positive or negative situation occurred that day that might have influenced their mood in a significant way. This was meant to ensure an easier detection of factors not directly related to work activities influencing a participant's mood (for example, feeling sick that day). The DSI should be filled out using a web form triggered by an email reminder at 18.15 each evening over the whole duration of the study.

CONCLUSIONS

We presented a framework that uses technological advancements for monitoring daily routines and parameters that may influence workers' mood. For inferring the current mood state we rely on existing methods of self-reporting – questionnaires that should report on subjective feelings. The goal is to uncover correlations between mood states and daily routines at work. In addition, we aim to find possible causes of both good and bad mood and to provide interventions to improve workers' well-being. The advantage of our design lies in monitoring subjects in an unobtrusive manner that does not affect their behavioral patterns while describing activities objectively in comparison to subjective self-reporting. We will present the results of our study during the workshop presentation.

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