MOBILE AGENTS IN CRISIS SITUATIONS – ADAPTING INFORMATION TO USER'S AFFECTIVE STATE

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ABSTRACT

Emotion has been found to influence humans' cognitive information processing and decision-making (Schwarz, 2000). A state of sadness, for example, is accompanied by substantive information processing, with greater attention to detail, whereas people in a happier state tend to process information more heuristically. Mobile applications or services presenting information to users, especially those used primarily in emotionally laden contexts, could adapt information presentation to users' current emotional state to improve compliance. This paper reports the results of an 2x2 between-subject survey experiment (N=91) with affective state (happy vs. sad) and information presentation style (heuristic vs. substantive) as dimensions. The results confirm that participants in a sad affective state are more likely to comply with mobile agents' advice when information is tailored to a substantive processing style. They base decisions on substantive information and provide longer descriptions. In contrast, people in a happy affective state prefer heuristic information. These findings reinforce the importance of affect-sensitive adaptation, especially for mobile agents in potentially emotionally laden contexts.

KEYWORDS

Adaptive User Interfaces, Information Presentation, Affect, Cognitive Processing style

1. INTRODUCTION

In urban, industrialized areas the separation between industrial areas and the places where people live and recreate is disappearing. This urbanization, caused by the lack of building space, the need for shorter commutes, and the fact that cities tend to increase in size and grow together, is the reason for people to start living closer to offices, plants processing chemicals and other industrial factories. Living, working or recreating nearby these facilities increases the risk for personal and environmental health, especially if an incident occurs in one of the facilities processing potentially dangerous substances. Providing information to the general public on how to react when such an event occurs is crucial to prevent people from panicking and bringing themselves, others, and the environment in danger. In order to determine how to respond sensibly to hazardous situations, information obtained from the same general public can be a valuable resource.

Members of the public as well as governmental agencies could equally benefit from location-based information sharing for reliable and efficient early detection and tackling of (incidental and long-term) pollutions and hazardous incidents (e.g., gas spills or chemical accidents, but also earthquakes or fires). Location- and context-aware mobile services offer the promise of adapting to a user's needs and tailoring information to her current situation. The anticipated ubiquitousness of these services on mobile devices means that citizen participation in environmental monitoring activities could become much more effective in the near future.

Such location-based information can be especially useful for emergency services, such as environmental protection agencies, fire fighters or police, in crisis situations. In addition to information from environmental sensors and meteorological data, automated services could use local observations to gain a more detailed overview of the situation and in turn inform crisis response activities (Winterboer et al, 2009). Such remote systems will interact with members of the general public rather than trained professionals, in contexts that can potentially be highly emotionally charged. In these contexts people may experience strong emotions and stress, which can reduce their ability to provide reliable information. Affective states have been shown to considerably influence cognitive information processing and decision-making (Schwarz, 2000).

If semi-autonomous remote systems interact with people via their mobile phones on behalf of emergency services in a crisis situation or during an environmental incident, it is crucially important to understand how people's affective state will influence the way they process and provide information as well as how it affects compliance to system instructions because in the not so far future semi-automatic incident detection systems will undoubtedly depend on information from these 'human sensors' and following their instructions might be vitally important.

This paper reports the results of an online survey experiment examining whether people in two different affective states will respond differently to information and instructions provided by automated systems through their mobile phones. The study is carried out in the context of environmental pollution in an urban-industrial area.

2. THEORETICAL BACKGROUND

When talking about affective states in this paper, our main focus is on emotions rather than moods. Although often used synonymously, mood and emotions are two different concepts (Oliveira and Sarmento, 2003; Dunn and Schwarzer, 2005). Oliveira & Sarmento divide emotional phenomena in three different categories, of which *specific emotions* and *moods* are the most relevant for this study. The specific emotions category consists of emotional phenomena or basic emotions (Frijda, 1986), such as anger, fear, and joy. They can be clearly differentiated, although an exact set of these emotional phenomena is still not defined. Emotions are typically shorter in duration than moods. Because emotions are usually very intense (Dunn and Schweitzer, 2005), normally emotional phenomena are normally perceived consciously by humans, although sometimes not immediately (Oliveira and Sarmento, 2003). Emotions also have well-defined objects or causes, in contrary to moods, which may not have a clearly defined cause. Moods can last for hours or even days, while emotions usually only last for seconds or minutes and are less consciously perceived than emotions

Picard's work on affective interfaces is considered the foundation of research on affective computing (Picard, 1995). Adapting to user's affective state shows great potential for improving interaction with semi-autonomous systems. Nass et al's experiments with either mood-congruent or mood-incongruent in-vehicle systems (Nass et al, 2005) have shown the usefulness and importance of adapting to users' emotional state; drivers had fewer accidents, attended more to the road, and spoke more to the system. Promising results were also found in the context of embodied conversational agents that adapt their dialogue style to the user's affective state (Cavalluzzi et al, 2003). Hudlicka describes an adaptive interface capable of adapting its information presentation style to users' affective and belief state by highlighting cues or displaying specific screens and found specific requirements for affective adaptive interfaces such as limiting the number and type of affective states, and using multiple information sources to assess the users' affective state (Hudlicka, 2000).

Datcu and colleagues (Datcu et al, 2007) introduce a multi-modal user-adaptive system for the crisis response domain enabling its users to make use of a device supporting pen-based graphical user interface that allows picture taking and speech in- and output. Its interface can adapt to the conditions in the working environment (based on GPS) and to the user's preferences and abilities. For example, different views are displayed depending on who is using the system (e.g., firemen or civilians) enabling firemen to reliably report released gasses (because of their expertise) by showing related icons, while preventing civilians from submitting unreliable information because these specific icons are hidden from them.

Affect influences both information processing (how people receive, store, integrate, retrieve, and use information), and subsequent behavioural responses (Forgas, 1995). Effects of affective states are especially apparent during heuristic or substantive processing (Forgas and Bower, 1988; Bower, 1991). People in a sad state are more likely to adopt a systematic, substantive processing strategy in which information is processed bottom-up (Schwarz, 2000). This processing strategy starts with the recognition of a stimulus and then builds up, with the help of memories and previously learned concepts, into higher-order perceptions and a final interpretation (Norman and Rummelhart, 1975). During this process attention is paid to details, such as the cause of a stimulus and its specific characteristics. Individuals in a happy affective state in contrast are more likely to adopt a top-down, heuristic processing strategy in which situation cues invoke simpler decision rules and people are less likely to engage in an effortful cognitive search. Examples of such heuristics are 'experts can be trusted' or 'attractive people are sociable' (Eagly and Chaiken, 1993; Shrum, 2001). In summary, previous research indicates that a happy state elicits a heuristic information processing style, while sadness elicits a substantive information processing style.

3. HYPOTHESES

We anticipate that people will be more responsive to information congruent with their affective state. For a system that instructs people, we predict that people are therefore more likely to comply with the system's instructions when information is provided congruent to their affective state. The rationale for choosing happy/sad was fed by our interest to build an autonomous system for environmental monitoring and alerting adapting its content presentation to users' affective state. Rather than focusing on the entire spectrum of emotions we decided to examine the affective binary (happy - sad) that was found both highly influential in previous research (e.g., Schwarz, 2000) and easy to induce (e.g., Rottenberg et al, 2007), because there would have been no need to look at other, more subtle affective states if our adaptations had not made a difference with these fundamentally different emotions.

H1: When people are in a sad state, they are more likely to comply with a system's instructions and requests when it provides substantive information, while people in a happy state are more likely to comply with systems that present heuristic information.

Because people will be more responsive to information congruent with their affective state we also predict that when confronted with both substantive and heuristic information, the information congruent with the user's current affective state will be more salient during decision-making.

H2: When people are in a sad state, they will perceive substantive information as more relevant for their assessment of a situation, while people in a happy state will focus more on heuristic information.

Since people tend to process information according to their affective state, we anticipate that they will process the events around them in a similar manner. Therefore, when requested to provide information, we expect people in a sad state to provide mostly substantive type information and those in a happy state to provide mostly heuristic type information.

H3: When people are in a sad state, they will provide mostly substantive information, while people in a happy state will mostly provide heuristic information.

4. METHOD

The experiment described in this paper has a 2 x 2 between-subject design. Independent variables were affective state (happy vs. sad), and information tailored to a specific processing style (heuristic vs. substantive). Within an interactive online survey we exposed participants to a fictitious incident scenario and information on a mobile phone through on-screen mockups embedded in the online survey (see Figure 1).

4.1 Participants

160 participants participated voluntarily in this online experiment. The largest identifiable group among them were [removed for blind review]. Data from 60 participants was excluded because they did not finish the questionnaire; data from further 9 participants was removed because they self-reported to be in the opposite emotional state than intended. The remaining 91 participants (69 males, 22 females) had an average age of 25.2 and were experienced mobile device users (M = 4.18, SD = .85, range: 1-5). Furthermore, participants were relatively well-educated (about 75 per cent of participants either had already or were about to obtain a university degree). Each participant was randomly assigned to one of four conditions ($N_{Happy\&Substative}$ = 23, $N_{Happy\&Heuristic}$ = 25, $N_{Sad\&Substative}$ = 22, $N_{Sad\&Heuristic}$ = 21).

4.2 Manipulations

4.2.1 Inducing Affect

In order to evaluate the effects of negative and positive affective states, we chose to induce two contrasting positive and negative emotional states, namely sadness and happiness. Literature offers a broad range of emotion inducing methods, for example imagery, music, and film. Previous research indicates that exposing participants to a movie is a particularly effective method to induce affective states (Gross and Levinson, 1995). Rottenberg and collegues (Rottenberg et al, 2007) provide an overview of reliable emotion eliciting movie clips, assigned to specific emotions.

In the survey, participants were first exposed to a 'neutral' video clip, which was a 64 seconds outtake from a National Geographic documentary about Australia's Great Barrier Reef that was tested and used in several similar studies (e.g., Cryder et al, 2008, Gino and Schweitzer, 2008). Based on Rottenberg et al.' findings, a happy affective state was induced by exposing participants to a short section (155 seconds) of the movie *When Harry Met Sally* (the "orgasm scene") as well as 152 seconds of a Muppet Show sketch (the song "*Mahna Mahna*"). A sad affective state was induced by showing 171 seconds of the movie *The Champ*, in which a boy is in tears while watching how his father passes out and dies, and the animated movie Bambi, in which Bambi's mother is killed by a hunter (134 seconds). All video clips were embedded in the survey.

4.2.2 Tailoring Information to Cognitive Processing Style

Although concrete examples of information tailored to a specific processing style could not be identified in the literature, we focused on characteristics of information that people take into account while processing information heuristically or substantively. For example, complexity of the text as well as personal relevance is important in substantive type information. In (Williams-Piehota et al, 2003), for example, messages about personal health were tailored to persuade individuals to engage in health activities by varying both the number of details (more in the substantive condition) and number of peripheral cues (more in the heuristic condition). Messages in the substantive condition emphasized facts and details related to the participant's situation. We adopted this approach when developing information for the current study.

Messages in the heuristic condition contained fewer facts and details. Peripheral cues were provided as well, by, e.g., by mentioning that information was based on experts' or celebrities' advice and observations were made by several persons. Table 1 provides sample messages containing either substantive or heuristic information about a gas leakage.

Table1: Sample messages with substantive and heuristic information

Information type	Example message
Substantive information	*A gas leakage has occurred during shipment at a chemical plant 100 meters north from your current location. 55 People have already left the area. Two liters of Hydronol gas leaked, which is toxic and causes teary eyes.*
Heuristic Information	*A gas leakage has occurred at a chemical plant, north of your current location. Several people, including the famous artist Tim Hayes, have left the area. According to experts the gas is harmful.*

4.3 Tasks and Procedures

Participants were asked to complete an online survey, and were randomly assigned to one of four experimental conditions. They provided demographic information (gender, age, nationality, highest level of completed education, and previous experience with mobile devices) and were then shown first a neutral and then an emotion inducing video clips. Next, they were requested to carry out three main tasks in the experiment. In task a), participants were presented with an image of a mobile phone which displayed information about a chemical gas leak as well as the instruction to leave the area or, alternatively, go inside and close doors and windows (see Table 1 and Figure 1).

Figure 1: Mobile agent presenting textual information about an incident.

The presented message was either tailored for substantive or heuristic processing. Based on this information participants had to indicate to which extent they would follow the mobile agent's advice. In task b), preceded by another emotion inducing video, participants were presented with a mobile phone interface that showed eight pieces of information (in two different orders) they would consider most relevant to them in such a situation. Four of the eight pieces offered substantive type information; the other four offered heuristic type information. Finally, in task c), participants were asked to describe an image presented by the mobile agent on the mobile phone's screen showing a gas station on fire, a wounded person lying on the ground, heavy smoke, and several other details about the incident 2 (see Figure 2).

Figure 2: Mobile agent presenting image of fire incident at a gas station.

`In summary, participants were asked to 1) provide demographic information about themselves, 2) watch first a neutral and then an affect inducing video, 3) carry out task a), 4) fill in a post-task questionnaire, 5) watch an affect reinforcing video, and 6) carry out tasks b) and c).

4.4 Measures

Compliance with the mobile agent (task a) was measured with a seven-point Likert-type scale that measured the extent to which a participant was inclined to follow the agent's advice to leave the area or to go inside, and to close doors and windows.

Heuristic or substantive information preference (task b) was measured by asking participants to select the most relevant pieces of information (with a maximum of three out of eight provided pieces of information). Each of the pieces of information had been designed to be strongly substantive or strongly heuristic based on the examples that could be identified in the literature (Schwarz, 2000; Eagly and Chaiken, 1993; Shrum, 2001; Williams-Piehota et al, 2003). The collective 'substantiveness' score of the three pieces of information selected as most relevant by the participant were averaged on a seven-point scale.

Heuristic or substantive description (task c) measured whether descriptions provided by participants were of heuristic or substantive nature by scoring the descriptions provided by the participants and calculating an average score. Descriptions were first divided into meaningful atomic segments (e.g., 'huge fire', 'petrol station sign'). Scores ranged from 1 (clearly heuristic: very unspecific, global and lacking details, contains heuristics, e.g. "an incident") to 5 (clearly substantive: very detailed and specific, containing exact numbers of objects or sizes, and specific locations, e.g. "three huge fires, of six meters height"). Two coders scored the descriptions provided by participants, with an intraclass correlation coefficient of .839 (which is acceptable according to (Nückles et al, 2006)).

5. RESULTS

To check the affective induction manipulation, participants were asked to self-report their affective state on self-assessment mannequins. Participants were requested to answer the question "How do you feel?" on a five-point picture-oriented Likert-type scale ranging from 'happy' to 'sad' (Lang and Bradley, 1994). A Mann-Whitney test confirmed that the manipulation of affective state was successful (Mdn = 2, M = 1.67, N_{Happy} = 48) and (Mdn = 4, M = 3.70, N_{Sad} = 43), U = 51, p < .000.

Due to the non-parametric distribution of the data, Kruskal-Wallis and Mann-Whitney tests were used for analysis. We found that *compliance with the agent* was significantly affected depending on whether the information was presented congruent with the processing style associated with a participant's current affective state, supporting Hypothesis 1 (H(3) = 6.263, p = .046). Compliance was significantly higher when sad participants were provided with information tailored for substantive processing, rather than with information tailored for heuristic processing (U = 203.5, p = .031). For happy participants, however, tailoring information did not affect compliance. Because such an effect was not found for happy participants, Hypothesis 1 was only partially supported.

Hypothesis 2 predicted that participants in a sad state (in comparison with participants in a happy state) would find substantive information more relevant than heuristic information, and vice versa. Indeed, happy participants (Mdn = 1, M = 1.33) selected significantly more information items tailored for heuristic processing than sad participants, who selected mostly substantive information items (Mdn = 1, M = .57; U = 849, p = .035). Therefore, the results support hypothesis 2.

According to hypothesis 3, people were more likely to provide information matching the processing style associated with their current affective state (substantive in sad states; heuristic in happy states). The descriptions provided by participants contained factual descriptions, but also reasoning about the situation depicted in the provided image. We found no significant differences for our measure of heuristic vs. substantive descriptions between the groups. However, we did find that sad participants used considerably more words (Mdn = 21, M = 21) to describe the presented image in comparison to happy participants (Mdn = 11, M = 15; U = 667, p = .012). We believe that more extensive descriptions are a feature of substantive descriptions. The findings thus partly support hypothesis 3.

6. DISCUSSION

Our results show that happy participants preferred information tailored for heuristic processing (which suggests that they require basic information to evoke simple rules-of-thumb) whereas sad participants preferred information tailored for substantive processing (suggesting a need for more detail and specifics). Moreover, we found that especially for sad participants, offering substantive information increases compliance to autonomous systems' advice. In emergency settings it is likely that people experience negative emotions and adherence to safety instructions is potentially vitally important. Therefore, adapting information presentation to the user's affective state is relevant and could potentially save lives.

When asked to provide information to the mobile agent, sad participants provided longer descriptions than happy participants, consistent with expectations of a more substantive processing style.

The study's limitations include its survey-based design and on-screen mock-ups of mobile interfaces. Therefore, more research is needed to verify these results with information provided on actual mobile devices aiming at obtaining actual behavioural data. The current findings indicate a substantial effect of participants' affective state on the way they process the information that is provided on a mobile device.

In future work, we plan to evaluate the effectiveness of adapting to users' affective state in more natural settings where emotions are not artificially induced and, in addition, we plan to take into account multiple (levels of) emotions and/or participants' stress level.

7. CONCLUSION

In this paper we investigated whether mobile agents should adapt to users' affective states by tailoring information to the cognitive processing style that corresponds with users' current affective state. Whereas earlier studies identified a number of characteristics of heuristic and substantive information, they did not develop and subsequently test concrete examples. In this study, we confronted people with information tailored to the processing style 'matching' their emotional state and measured responses to investigate whether participants would tend to offer more reliable information or comply more with the system.

The context of this work is an autonomous decision-making system that uses information from people through their mobile phones to assess the nature, location, and seriousness of environmental incidents (e.g., gas spills), predicting the incident's future development based on, for instance, meteorological data, and alerting people by sending information about new developments or rescue instructions, if required. If such an autonomous system bases decisions on data from 'human sensors' it should be able to interpret information from its users as reliably as possible. The knowledge that a user is currently in a certain affective state (for example, sad) could mean that she is likely to provide information in a specific way (substantively) allowing assessing the reliability of information provided by this person more effectively. Similarly, knowledge about the user being in a certain emotional state allows the system to send instructions in a style congruent to a user's emotional state to increase compliance with the system's instructions and thus human safety.

Based on the results of this study, we recommend that mobile agents, especially those interacting with members of the general public in potentially emotionally laden contexts, should adapt the way they present information to the affective state of their users.

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