Reducing the Negative Effects of Interruptions with Mobile Agents' Social Behaviour

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Abstract. In the near future, intelligent agents on mobile devices will push to as well as request location-dependent information from users at convenient and inconvenient times. In this paper, we consider the negative effects of mobile agent interruption and present strategies to reduce these effects drawn from social psychology and task-interruption literature. We propose the implementation of social behaviours to minimize the negative effects of (task) interruptions caused by mobile agents and report the results of two studies that evaluate two social behaviours agents can adopt. The results from these studies indicate that a mobile agent adopting social system behaviour can lead to a less disruptive user experience.

Keywords: Task interruptions, social behaviours, mobile agents

1 Introduction and Related Work

Already today, due to the increasing availability of social networks and news services for mobile devices, services push potentially relevant information to mobile phone users. Typically, these messages are accompanied by sound or vibration alerts that may be very distracting if the user is in a meeting or in a quiet environment.

In the near future, however, we expect that even more services and mobile agents will contact users to either offer information and services or to obtain information from users. Winterboer et al. [1] introduced an autonomous system that in case of unusual readings detected from environmental measuring sensors calls people in or around affected areas to gain more information about possible gaseous pollution and provides instructions to people in case of an emergency. Such systems heavily depend on users responding and providing reliable information. These systems will interrupt people during their daily life and the aim of our research is to design the human-agent dialogue in order to minimize the negative effects of such interruptions.

System interruptions can cause feelings of frustration, distraction, and increase the time required to perform the primary task [2]. McFarlane [3] was among the first to predict the increasing role and disruptive nature of interruptions caused by newly emerging information technology. McFarlane and Latorella [4] showed that

unpredictable and uncontrollable interruptions induce *stress*, and can negatively affect *performance* after interruptions, cause people to *make mistakes*, and can reduce their *efficiency*. Iqbal and Bailey [5] reported elevated *annoyance* and *anxiety*, increased *error rate*, and decreased *performance* and *decision making* as negative effects of interruptions. Other studies found negative effects of interruptions on memory [6] and that users lose considerable time when having to switch between tasks [7].

According to Clark [8], people normally negotiate human-human interruptions. Social conventions dictate the most appropriate time for one person to interrupt another [9]. These conventions, together with the reaction of the person who has been interrupted, allow an evaluation of whether or not an interruption is appropriate. However, determining when to interrupt users is much more challenging for services or applications because in contrast to humans these applications cannot simply utilize long-established knowledge about social conventions.

Hudson et al. [10] showed that users' emotional state is an important factor influencing the effects of interruptions. Their research indicates that in order to recover from task interruptions, goal rehearsal (e.g., using visual cues to highlight the next logical step) can help greatly to reduce these effects. Furthermore, context loss is often caused by long delays associated with task switching and visual cues can serve as reminders to return to suspended applications [6].

Table 1. Negative effects of (task) interruptions and human- as well as system strategies to mitigate these negative effects

Negative effects (on)	Human strategies to mitigate disruption	System strategies to mitigate disruption
• Task resumption lag and task related memory loss [5, 7], • Emotional state (e.g. annoyance, anxiety) [4,12], • Task performance [12].	• Negotiate time of interruption [8], • Use knowledge about socially acceptable times to interrupt [9], • Social behavioural strategies, empathy, politeness, praise [11]	• Assess appropriate time to interrupt (late, at break-point, at low cognitive workload) [4, 5, 7, 12], • Offer visual cues [6], • Rehearse task [10], • Negotiate interruption [8].

As can be seen from Table 1, current system strategies focus on knowing *when* to interrupt, help users recover *after* interruption and *negotiate* interruptions. Humans, however, use a variety of social strategies to *mitigate* interruptions, such as expressing a request for interruption with politeness or empathy, or interrupting with certain non-verbal behaviours. McFarlane [4] summarizes those findings of Brown and Levinson's [11] seminal work on Politeness Theory that are related to human strategies of interruptions. They argue that interruption is a kind of communication act (a face-threatening act), and that the way the interruption is expressed (i.e., the deliberative decision on how to construct the message) determines its effect on social relationships. They also propose a taxonomy of polite interruption strategies, divided into, among others, positive (e.g., using praise: "Hey, your idea worked great! Let me tell you what happened ...") and negative (e.g., empathic/apologetic: "Please forgive me for interrupting.") politeness. We expect that mobile agents that interrupt users with location-dependent information or requests will be able to similarly mitigate the negative effects of interruptions by adopting comparable human social behaviours.

Apart from knowing when to interrupt and helping users recover from interruptions, such agents should therefore also know 'how to interrupt' and adopt social behaviours to reduce negative effects of interruptions and increase user responsiveness and reliability of user responses. For example, Picard and Liu [13] tested a system that utilizes information about participants' current stress level (based on sensor data) when interrupting either empathically or not and found a general preference for the empathic version. They found that the interrupting system adopting empathic system behaviour led to fewer perceived interruptions than a neutral system. However, these findings are based on data from only ten participants.

2 Mitigating interruptions with empathic and motivational system behaviour

We assessed the effects of empathic mobile agent interruptions on user attitudes (reported in detail in [14]). A mobile agent frequently interrupted participants (N=44) with requests during a search and recovery task in a maze. Participants were exposed to two conditions, a mobile agent that communicated with empathic text messages ("Sorry to interrupt you, but...") and a neutral agent. Results indicate that empathic agent behaviours did not lead to more positive user attitudes. Moreover, the empathic agent was perceived as equally disruptive and led to reduced trust in the information provided and less compliance to the system's warnings. These findings show that users may experience empathy as irritating and superfluous, and in order to reap the potential benefits of empathy, messages need to be designed with great care taking into account the individual user and her context.

In a second study [15], we studied the effects of socio-psychological motivational strategies on user attitudes in a longitudinal field study. Participants (N=40) were interrupted by and communicated (textually) with either a neutral or a motivating air quality detection agent for the early detection of environmental incidents via their mobile phones. They did not generally show more positive attitudes towards the agent that adopted motivational strategies (e.g., praise: "…That was yet another useful contribution of you - excellent." or social comparison: "…Your performance was among the top ten on the smell description task") in its responses, but were more interested in keeping in touch with it and perceived it as less disruptive in comparison with participants communicating with the neutral agent. This is an encouraging result demonstrating that agents' social dialogue behaviour informed by social psychology can mitigate negative effects of interruptions.

3 Discussion and Conclusion

Although our experiments so far yielded mixed results, we feel it is important to continue research into social behaviours to mitigate negative effects of interruptions by location-dependent mobile services. In the experiment in which empathic mobile system behaviour negatively influenced user attitudes and compliance, comments in post-interviews suggested that the empathic system responses were sometimes

considered repetitive, sarcastic, or over the top (i.e., not genuine). However, this does not mean that in general mobile agents' adopting social behaviours negatively affect user attitudes. Considering the positive effects of empathy in human-human interaction, we still expect that appropriate empathic behaviours will help to mitigate negative effects of interruptions. In fact, the results of our second study demonstrate that social behaviours may potentially reduce disruptiveness. Thus, social expressiveness has great potential to mitigate the negative effects of interruptions. However, careful message construction is crucial as inappropriate social expressiveness clearly has negative consequences. Therefore, we argue for the implementation of social strategies and stress the need for future behavioural experiments to inform the design of social behaviours for interruptive mobile agents developed for (long-term) collaboration with human users.

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