Personalized Persuasion in Ambient Intelligence: The APStairs System

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Abstract. Can ubiquitous technologies intended to change people's behavior benefit from personalization? This paper addresses the development of an *adaptive persuasive system* intended to increase stair climbing at work: APStairs. Based on their *persuasion profile,* individuals are distinguished by their susceptibility to different social influence strategies. This paper contributes a first application of persuasion profiling in the domain of ambient intelligence; it reports the deployment of the APStairs system in a real life setting for a period of five weeks involving 34 participants. Although a longer deployment period is needed to statistically validate the system, this first deployment of the system has shown the feasibility of adaptive persuasion.

Keywords: Persuasive Technology, Adaptive Persuasive Systems.

1 Introduction

Ambient technologies open up the possibility of influencing human behavior by providing persuasive content, sensitive to human activity and its context. This has been pointed out early on by Fogg [4], who emphasized the importance of delivering persuasive messages at the right place and at the right time to increase compliance. The field of ubiquitous technologies needs theoretical and methodological guidance for the design of persuasive systems. Such guidance has been traditionally imported from social sciences; see [5], but also [3] for some alternative perspectives on design strategies.

In this paper, we focus on the application of social influence strategies in ambient intelligence. Social influence strategies are extensively researched in the field of social psychology and compose different means to reach a pre-defined end. We explore the ways in which ambient systems can adapt their approach(es) to influence user behavior based on the behavioral responses of the user.

In our design, we adopted three of the six social influence strategies identified by Cialdini [2]: *Authority* (when a request or statement is made by a legitimate authority, people are more inclined to comply), *Commitment and Consistency* (people do as they said they would), and *Consensus (*people do as other people do). Each of these strategies can be utilized to increase compliance, irrespective of the target behavior of the persuasive attempt.

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The effectiveness of these influence strategies has been shown at an *average* level (i.e., over groups of people). However, when studied in more detail, there appear to be large differences in the responses of *individuals* to implementations of these social influence strategies [1]. Besides, Kaptein et al. [5] and [6] have shown that people have preferences for *distinct* influence strategies, and using the *wrong* strategy for a specific user can have a negative effect at individual level, even when the average compliance of this strategy is positive. This suggests that to increase the effectiveness of persuasive applications, influence strategies should be adapted to individual users.

An *adaptive* persuasive system, one that is responsive to the presence of users and automatically adapts the way in which a behavior is promoted on individual basis, has not yet been implemented, and automated adaptation at the level of influence strategy usage has not yet been explored in a real life setting. We define adaptive persuasive systems as *systems that select the appropriate influence strategy to use for a specific user based on its estimated success*. We identify three key functional requirements such systems should embrace: (1) *identification*: identify individuals, (2) *representation*: represent one end goal through various social influence strategies, and (3) *measurement*: measure the persuasive attempts' outcomes to adapt to individuals.

2 The APStairs System

APStairs is an adaptive persuasive system**,** designed to encourage people to take the stairs rather than the elevator. To unobtrusively *identify* unique users, Bluetooth inquiry-based scanning was used. Globally unique Bluetooth addresses of discovered Bluetooth-enabled mobile phones, together with their timestamps were stored.

Messages that aimed at persuading people entering the building to take the stairs instead of the elevator were *represented* on a large screen in the hallway of an office building. Per social influence strategy, three messages were created (see Table 1).

Table 1. Messages shown to users of the APStairs system: Each message implements one of the three social influence strategies to increase compliance

Persuasion strategy	Message
Authority	1. "You get a good exercise by taking the stairs instead of the elevator." – Bert Clarenbeek, gym instructor
	2. Doctors recommend taking the stairs.
	3. "Taking the stairs helps you shape up your buttocks." – Jessica de Groot, zumba instructor
Commitment and Consistency	4. Planned to become healthier? Start by taking the stairs!
	5. Committed to get in shape? Start by taking the stairs!
	6. Promised yourself to be more physically active? Take the stairs!
Consensus	7. 70% of the people in this building already take the stairs. What about you?
	8. The majority of the people in this building takes the stairs. Join them now!
	9. Follow many other people; take the stairs!

Given our context, we defined a message to be successful for an individual if after the message was shown, he or she took the stairs. To *measure* the success of different messages, scanners were installed on every floor of a five-story office building. Each scanner independently scanned for nearby Bluetooth-enabled mobile phones and uploaded its results to a central server. Figure 1 schematically shows APStairs.

A simple adaptation method was implemented to select the messages. We modeled the probability of success of a message as binomial random variable, $B(n,p)$, where n denotes the number of times a message that implemented a specific strategy (e.g., *Authority*) was shown to a user, and p denotes the probability of success (i.e., the user took the stairs). Given M different influence strategies – three in our setup – one can compute for each individual i, for each strategy m, the probability $p_{mi} = k_{mi} / n_{mi}$, where k_{mi} is the number of observed successes after representation of strategy m, n_{mi} times to a specific user i.

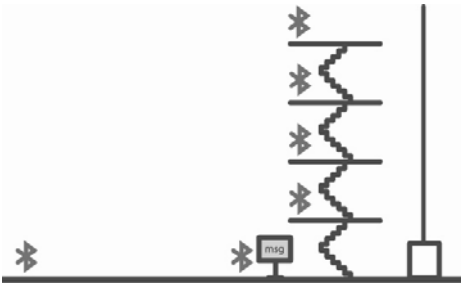

Fig. 1. Overview of the APStairs system: Users entering the office building are recognized by the first bluetooth scanner (left). Next, they are presented a message encouraging them to take the stairs. Finally, scanners in the stairway measure the success of the message.

We then used a Beta-Binomial model to track the estimated effectiveness of a single strategy over time points for a single user. Messages for users entering the lobby were selected not just based on the expected value of the distribution, but also based on that estimate's certainty. New users of the APStairs system were not by default shown a *Commitment and Consistency* implementation (highest estimated probability of success based on a pretest of the developed messages), but rather a random message was selected if the *80%* confidence intervals of the estimates of strategy effectiveness overlapped. This *80%* bound was used early in the deployment of the system to get information about each of the strategies from each user (*explore* period). After running the system live for three weeks, this uncertainty bound was decreased (to *20%*) to *exploit* the knowledge gained about individual users. The collection of estimates of the success of different social influence strategies for a specific user is called a *persuasion profile.*

3 System Evaluation

To evaluate the APStairs system, we employed it for five weeks in an office building. Users – people entering the building whose mobile phone's Bluetooth key was

scanned – were randomly assigned to one of two conditions: (1) the *adaptive condition*, where the system chose a random message belonging to the persuasion strategy with the highest probability of success for the identified user, and (2) the *non-adaptive condition*, where the system chose a random message. Each user was presented messages that were selected based on their condition. For users in the *adaptive* condition, a persuasion profile was used to select the most appropriate social influence strategy. Subsequently, the behavioral response was recorded and the persuasion profile was updated.

3.1 Preliminary Results

To see whether there was a difference in compliance to persuasive messages between the two conditions, the proportions of stair taking were calculated for each user. Even though the estimated success-rates of the two systems seemed to diverge according to our expectations – with the adaptive version of the system being more successful – this trend was not statistically significant; the results suggest the need for a longer term deployment of the system that involves a larger number of participants.

However, to illustrate how APStairs functions for users in the adaptive condition, the history of one of our participants, 'user 94', is presented in Figure 2.

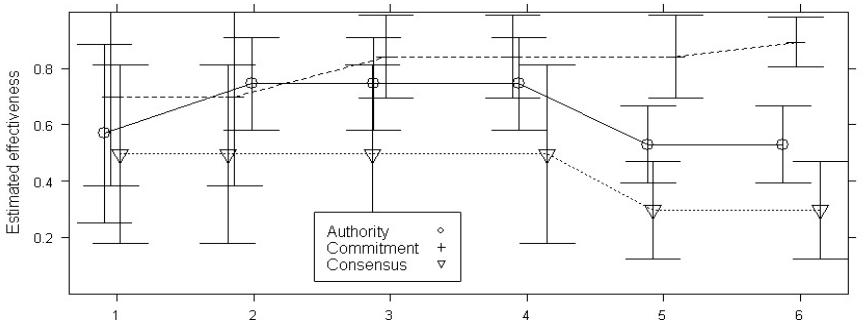

Fig. 2. Estimates of the effectiveness of the different strategies for user 94. It is clear that the commitment and consistency strategy is most effective for this user.

For user *94*, the first message that was presented implemented the *Authority* strategy, which was successful and thus raised the estimated success of this message. During the second visit, a message implementing the *Commitment and Consistency* strategy was shown, which was also successful, increasing the estimated success for this message. Next, the user received an implementation of the *Consensus* strategy, which was unsuccessful. On his or her last visit an implementation of the *Commitment and Consistency* strategy was shown. As expected, this last message was successful.

After the quantitative evaluation a total of *12* (possible) users (i.e., office workers entering the building at the day the system was dismantled) were interviewed. Overall, users commented that the messages were delivered clear in sight and precisely at the moment when the decision to use either the stairs or the elevator was taken. Moreover, the timing and duration of the messages was found to be adequate, and the content indeed triggered people's consciousness about stair taking behavior.

4 Discussion

We deployed an adaptive persuasive system created to increase stair usage amongst office workers in a real life setting for several weeks. This first deployment of the system has shown the feasibility of adaptive persuasion, illustrating how different strategies can be implemented and selected in accordance to the user's behavior. Our field test showed that for a good number of individuals, the system converged to their personal most successful strategy. We hope that this demonstration and description of the implementation of our adaptive persuasive system encourage designers of persuasive technologies to use personalization at the level of social influence strategies to increase the effectiveness of their systems.

While we succeeded in building the first adaptive persuasive system that personalized its influence strategies – as opposed to the end goals – to responses by users, it should also be noted that our setup and evaluation have limitations. Most importantly, we suffered from an insufficient number of observations to successfully evaluate the system. Although the number of users entering the building was rather large, the technology excluded around 90% of the potential users: those who did not have Bluetooth enabled phones. Furthermore, the duration of the deployment was too short to fully explore users' susceptibility to different influence strategies and *exploit* them in full to create valid comparisons between the two conditions in the evaluation.

While promising, persuasion profiles and their use in adaptive persuasive systems should be looked at with caution. There are obvious ethical considerations (especially when systems are used for less socially accepted goals), and the unobtrusive tracking processes pose serious privacy concerns that should guide future research efforts.

This paper presented our first steps in the exploration of adaptive persuasive systems. We hope to be able to deploy the APStair system for a longer period of time. This will lead to *(a)* a statistically valid comparison of the performance of an adaptive system to a random system, and *(b)* a better insight into the effects of different influence strategies over time.

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