Pervasive and Mobile Computing 10 (2014) 203–221

Contents lists available at ScienceDirect

Pervasive and Mobile Computing

journal homepage: www.elsevier.com/locate/pmc

Motivating the motivators: Lessons learned from the design and evaluation of a social persuasion system

Meng-Chieh Chiu [a,*], Cheryl Chia-Hui Chen [b], Shih-Ping Chang [a], Hao-Hua Chu [a], Charlotte Wang [b], Fei-Hsiu Hsiao [b], Polly Huang [c]

[a] Department of Computer Science and Information Engineering, National Taiwan University, Taipei, Taiwan
[b] School and Graduate Institute of Nursing, National Taiwan University, Taipei, Taiwan
[c] Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan

ARTICLE INFO

Article history:
Received 1 December 2011
Received in revised form 3 November 2012
Accepted 27 November 2012
Available online 29 April 2013

Keywords:
Persuasive technology
Ubiquitous computing
Social persuasion
Mobile computing
Activity recognition

ABSTRACT

This paper presents the lessons learned in designing and evaluating a social persuasion system. This social persuasion system, called the Playful Bottle, consists of a mobile phone attached to an everyday drinking mug, and motivates office workers to drink healthy quantities of water. This study discusses the results of a 10-week quantitative user study and qualitative focus group interviews. We describe how users interacted with one other through the system's care-giving and care-receiving interface and how the system's social effect influenced drinking behaviors. Based on our findings, we offer lessons learned on how to design an effective social persuasion system. The important lessons leaned in our finding: Motivate the motivator, reduce pressure and lessen the feeling of deprivation, and combine positive with negative reinforcements.

1. Introduction

Persuasive computing is using digital technologies to motivate people to change their behaviors. Designing effective digital persuasion systems and successfully changing people's behaviors are challenging tasks. Many digital persuasion systems [1–9] follow the "behavior detection and human feedback" model. The behavior detection part may employ either sensor-based activity recognition to automatically identify people's behaviors or rely on users to input their behaviors as a means to complement automated sensing [5]. The human feedback part often involves preprogramming interaction between users and the system, and applies a suitable persuasive tactic to influence users. Previous research in persuasive systems [2,3,8] shows that designing effective feedback mechanisms with humans is often more challenging than improving the sensing accuracy of machines through better sensors and activity recognition algorithms.

Several recent persuasion systems [4,7,10–12] explore social effects in their feedback design. Studies [7,13] have shown that it is possible to amplify a system's persuasiveness by transforming it into social interaction. The theoretical basis of social persuasion is derived from the theory of behavior change and social conformity. In theory of behavior change, it is based on the strong connection between people's attitude and behavior [14,15]. If behavior changes, for example by legal constraints, it may be expected that an attitude will change as follows. In theory of social conformity, it is based on the proposition that opinions and attitudes are constrained by the opinions of others and that many behaviors result from fear of peer

* Corresponding author. Tel.: +886 233664888 336.
E-mail addresses: terry3800@gmail.com, r96944046@csie.ntu.edu.tw (M.-C. Chiu).

1574-1192/$ – see front matter
http://dx.doi.org/10.1016/j.pmcj.2012.11.006

disapproval [16–18]. Conformity is a change in personal behavior due to group influence, which increases the congruence between the individual and the group [19]. In digital social persuasion systems, people play the primary role of motivating each other, and computers play a secondary role of facilitating or empowering people to become better motivators. Social persuasion systems often fail when there is insufficient enticement to motivate caregivers and promote their care-giving efforts. This paper demonstrates the importance of this "motivating the motivators" concept and reveals lessons learned from the design and evaluation of a social persuasion system called the Playful Bottle. We believe that the "motivating the motivators" concept is a critical factor in designing effective feedback interaction in a social persuasion system. As evidence, we report the findings of a 10-week experimental comparison study evaluating water drinking behavior among three randomized groups with 16 players involved, for which we collected and analyzed both quantitative and qualitative data.

The Playful Bottle [13] is a mobile social persuasion system that consists of a mobile phone attached to an everyday drinking mug. The goal of the Playful Bottle is to motivate office workers to drink healthy quantities of water. The mobile phone with its built-in sensing, processing, and displaying capabilities, achieves both sensing and feedback—creating an *all-in-one design*. For behavioral sensing, the camera and accelerometer sensors embedded in the phone form a vision/motion-based water intake tracker to detect the amount and interval of water consumed by the user. In our experiment, we included a control group in which there was a tracker to detect water consumption but no feedback from the system. For feedback and interaction, the phone displays two hydration games in which natural drinking actions are used as inputs to non-social and social persuasion games. In the non-social persuasion game, the system observes the water drinking behaviors of players and provides reminder feedbacks. In the social persuasion game, group members observe the water drinking behaviors of other players and exchange computer-mediated care-giving messages. Although comparison user studies between two persuasion games show that the social persuasion game was more effective in increasing the subjects' water intake than the non-social persuasion game, they also reveal the successes and failures of the design of the social persuasion game. One of the important lessons learned for the social persuasion game is the need to facilitate positive group dynamics by encouraging the caregivers and reinforcing their care-giving actions with timely rewards from the care-receivers or computers. This differs from traditional persuasive systems, which emphasize encouraging under-performing users, who are often the care-receivers in a social persuasive system.

The two important contributions of this work are as follows:

- This comparison user study presents results from a 10-week quantitative user study evaluating how the social and non-social persuasion games in the Playful Bottle system affect user drinking behavior. This comparison study also reports findings from qualitative focus groups, in which subjects were interviewed about their experiences using these games.
- We present lessons on how to design an effective social persuasion system as learned from the Playful Bottle system. We hope that others can apply these lessons in the design of future social persuasion systems.

The rest of this paper is organized as follows. Section 2 reviews related work. Section 3 provides a brief overview of the design and prototype of the Playful Bottle system. Section 4 details the 10-week user study and presents quantitative and qualitative results. Section 5 discusses lessons learned from the user study results. Section 6 draws conclusions and discusses directions for future work.

2. Related work

Many researchers have examined how persuasive technology can motivate behavioral change in our living environment. Their work can be divided into four categories: (1) design theories and strategies for persuasive technologies, (2) computer-mediated social persuasion systems targeting specific everyday behaviors, (3) non-social computer persuasion systems targeting specific everyday behaviors, and (4) smart cups sensing drinking behaviors.

Fogg [20,21], a pioneer in the Captology field (i.e., the study of computer-based persuasion), proposed a functional triad for analyzing how people view or respond to computers: as tools, as media, or as social actors. Different functions suggest different types or designs of persuasive influence. The Playful Bottle system functions as a tool that simplifies the self-monitoring of water intake volume through automated sensing and reminders. It also functions as a social actor that gives positive rewards for good behavior and provides social support through the social persuasion game. King et al. [22] described five persuasive strategies for using digital technology to change people's attitudes and behaviors, four of which are relevant to the proposed Playful Bottle system: virtual groups, simulated experience, surveillance, and an environment of discovery. The virtual group strategy motivates people through cooperation or competition in a group setting. The simulated experience strategy simulates an environment or object, sufficiently similar to its real-life counterpart, which enables users to experience the results of different behavior choices. The surveillance strategy uses monitoring and tracking to affect behavior. The environment of discovery strategy presents a fantasy environment in which positive rewards are given for good behavior. Oinas-Kukkonen et al. [23,24] extended Fogg's work [20] by developing a comprehensive framework that enables transformation of persuasion design principles into software requirements and system features. In particular, the Playful Bottle system matches all of the social support design principles in the framework: social learning, comparison and facilitation, normative influence, cooperation and competition, and recognition. Consolvo et al. [25] listed eight design strategies for persuasive technologies that target everyday use. The Playful Bottle system relates to three of the eight design strategies: abstract and reflective, unobtrusive, and aesthetic. The abstract tree presentation on the mobile display enables